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FUELING THE HIGH TECH WORKFORCE WITH MATH AND SCIENCE EDUCATION

FIELD HEARING

BEFORE THE

COMMITTEE ON SCIENCE
HOUSE OF REPRESENTATIVES

ONE HUNDRED EIGHTH CONGRESS

SECOND SESSION

JANUARY 23, 2004

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FUELING THE HIGH TECH WORKFORCE WITH MATH AND SCIENCE EDUCATION

FRIDAY, JANUARY 23, 2004

HOUSE OF REPRESENTATIVES,
COMMITTEE ON SCIENCE,
Washington, DC.

The Committee met, pursuant to call, at 9:20 a.m., in the Campbell High School Auditorium, Smyrna, Georgia, Hon. Phil Gingrey presiding.

COMMITTEE ON SCIENCE
U.S. HOUSE OF REPRESENTATIVES

Fueling the High Tech Workforce with Math and Science Education

January 23, 2004
9:00 AM
Campbell High School Auditorium, Smyrna, GA

Witness List

Ms. Rachel Purcell
Valedictorian, Class of 2004
Campbell High School

Mr. Randy McClure
Teacher and Department Chair for Science
Campbell High School

Mr. J. Martez Hill
Policy Director
Georgia Department of Education

Dr. Paul Ohme
Director, Center for Education in Science, Mathematics, and Computing
Georgia Institute of Technology

Mr. C. Michael Cassidy
President
Georgia Research Alliance

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HEARING CHARTER

COMMITTEE ON SCIENCE
U.S. HOUSE OF REPRESENTATIVES

Fueling the High Tech Workforce With Math and Science Education

FRIDAY, JANUARY 23, 2004
9:00 A.M.–12:00 P.M.
CAMPBELL HIGH SCHOOL,
SMYRNA, GEORGIA

1. Purpose

On Friday, January 23, 2004, the House Science Committee will hold a field hearing to examine various strategies underway to improve student achievement and teacher performance in math and science education. This hearing will also discuss the value of a well-educated science and technology workforce to job creation and economic vitality.

2. Witnesses

Ms. Rachel Purcell is a senior at Campbell High School. She is valedictorian of her class and she hopes to pursue a career in medicine.

Mr. Randy McClure is a teacher and the Department Chair for Science at Campbell High School.

Mr. J. Martez Hill is Director of Policy at the Georgia Department of Education.

Dr. Paul Ohme (OH-may) is the Director of the Center for Education in Science, Mathematics and Computing (CEISMC, pronounced "seismic") at the Georgia Institute of Technology. Prior to joining CEISMC, Dr. Ohme served as the Associate Vice President for Academic Affairs and the Head of the Department of Computer Science at Northeast Louisiana University. Dr. Ohme also taught mathematics and computer science at various colleges and universities, including Clemson, Mississippi, and Franklin and Marshall.

Mr. C. Michael Cassidy is the President of the Georgia Research Alliance. Before joining the Alliance, Mr. Cassidy managed the Advanced Technology Development Center (ATDC) based at the Georgia Institute of Technology, one of the Nation's oldest technology incubators. He also worked for IBM, where he held various staff and management positions. In addition to his work at the Alliance, Mr. Cassidy consults with several states on issues of science and technology policy and he represents Georgia on the Southern Technology Council and the Southern Governors' Association Advisory Committee on Research, Development and Technology.

3. Overarching Questions

The hearing will address the following overarching questions:

- How can federal, State, and local entities work together to attract and educate the next generation of scientists and engineering students? What strategies are being employed to increase math and science interest and achievement at the State and local levels?
- How important is a well-educated workforce to keeping the Nation at the forefront of research, development and ground-breaking advances in science and technology? What will happen if we cannot adequately develop our domestic talent?
- How can successes in these areas translate into economic gains and other opportunities for individuals, businesses, and the Nation as a whole?

4. Brief Overview

- The U.S. Department of Labor projects that new jobs requiring science, engineering and technical training will increase four times higher than the average national job growth rate. Clearly, workers increasingly require a solid academic foundation in science and math—as well as technical know-how—to succeed in today's high-tech workplace.

- This issue of national importance is especially important in Georgia, where the rapidly growing science and technology workforce is now the 11th largest in the Nation. In addition, Georgia is a leading State in emerging fields such as nanotechnology and 9th nationally in the emerging field of biotechnology.
- Despite these growing demands, only two out of every 100 high school graduates nationally will ever obtain an engineering or technical degree and only nine out of 1,000 women and eight out of 1,000 minorities will ever obtain an engineering degree.
- Further, most of the graduating class in America's high schools is either not sufficiently prepared or not sufficiently motivated to pursue advanced study in science, math, engineering or technology fields. According to the National Assessment of Educational Progress (NAEP), fewer than one-third of all U.S. students in grades four, eight and twelve performed at or above proficient levels, while a third performed below basic levels.
- While there are no quick fixes, we can take steps now to re-examine how teachers teach and students learn math and science. Successfully addressing these challenges will positively impact Georgia's economic growth and, consequently, the economic welfare and scientific discovery of the Nation as a whole.

5. Background

For decades, the United States has been able to conduct cutting-edge science because of its ability to both recruit talented American students into science and technology fields and import the best and brightest from around the world. Our well educated workforce has fueled the Nation's engine of economic growth, and it has propelled the U.S. to global leadership in science and technology (S&T). Unfortunately, a decline in our domestic S&T workforce, new restrictions on foreign-born individuals, and an increase in competition for S&T talent may make it difficult for the U.S. to maintain its edge into the future.

Student Achievement in Math and Science

The future of the Nation depends on a strong, competitive workforce and a citizenry well equipped to function in an increasingly complex and interdependent world. While the most recent results of the National Assessment of Educational Progress (NAEP) show that student achievement is generally up over the last 30 years, large numbers of U.S. students demonstrate a mastery of only rudimentary mathematics. In fact, 31 percent of 4th graders, 34 percent of 8th graders and 35 percent of 12th graders scored below "basic." Worse, the achievement gap in NAEP math scores between white and black students and between white and Hispanic students has remained relatively unchanged since 1990, with 68 percent of African American 8th graders scoring below basic compared to 23 percent of white students.

On international assessments, U.S. performance relative to other nations actually declines with increased schooling. According to the most recent (1999) Third International Mathematics and Science Study (TIMSS), an assessment that evaluates the math and science performance of 4th, 8th and 12th grade students from 42 different countries, most U.S. children score above average in elementary school, but those in 12th grade—including our most advanced students—rank among the lowest of all participating countries, outperformed by nearly every industrialized nation and ahead of only Cyprus and South Africa.

According to the TIMSS analysis, most U.S. high school students take no advanced science, with only 25 percent enrolling in physics and 50 percent in chemistry. These high school graduates are not prepared to study college level science or engineering and, in fact, are unlikely ever to do so.

While U.S. undergraduate and graduate education remains the envy of the world, the interest of and the participation by U.S. students in science, technology, engineering and math is declining. In fact, of the 25–30 percent of freshmen who express an interest in science and engineering, less than half complete a science or engineering degree in five years. As noted by the 1998 Science Committee study, entitled *Unlocking Our Future,* "There appears to be a serious incongruity between the perceived utility of a degree in science and engineering by potential students in the U.S. and the present and future need for those with training in our society." This is especially the case in emerging and interdisciplinary areas, such as nanotechnology, information assurance, and bioinformatics.

As the number of U.S. science and engineering students declines, our dependence on foreign students grows. According to the National Science Foundation's *Science* *and Engineering Indicators* (2002), the percentage of foreign-born individuals among scientists and engineers in the U.S. is growing at all degree levels, in all sectors, and in most fields. Especially high percentages are found in engineering (45 percent), computer sciences (43 percent) and mathematics (30 percent).

At the same time, other nations are aggressively acting to stem their own "brain drains" and entice citizens trained in the U.S. to return to their native countries, and many are succeeding. The Council of Scientific Society Presidents estimates that by 2010, if current trends continue, over 90 percent of all physical scientists and engineers in the world will be Asians working in Asia. New opportunities to do high wage, high value work without immigrating to the U.S. may reduce the net "brain gain" that has been so critical to our historic economic success.

Workforce

In December 2001, the Bureau of Labor Statistics (BLS) projected that the number of professional information technology jobs in the U.S. would grow by more than 70 percent between 2000 and 2010. (New projections in March 2004 will cover 2002 to 2012 and factor in the economic impacts of events and trends subsequent to the previous projects, such as the 2001 recession and the terrorist attacks.) With unemployment at six percent and a net loss of jobs since 9/11, the case for a shortage may be suspect. But, if the economy continues to rally, our need for qualified workers will grow.

Over the next fifteen years, 40 million workers will retire, but the growth in the number of workers between the ages of 25 and 54 is expected to be flat over that same period. This future shortage will be compounded by the fact that worker skills and education are not keeping pace with extraordinary technological advances in the workplace. According to the BLS, 15 of the 20 fastest growing occupations are expected to require substantial math or science preparation.

To remain competitive, we must do a better job of educating, hiring, training, retaining and advancing our workers. Our education and training programs must do more to prepare and connect workers to today's jobs and help them keep pace with the changing skill demands of the 21st century workplace. Also, businesses must look for workers in populations they have historically neglected, such as the 70 percent of people with disabilities who don't have jobs. Not only will this spur economic growth, but it also will provide greater opportunities for students to pursue higher education and training or to enter higher-wage careers.

Federal Math and Science Education Initiatives

K–12 Programs

In the mid-1980s, the U.S. Department of Education created math and science professional development programs, consortia and clearinghouses. Meanwhile the National Science Foundation broadened its math and science education focus to include all students—instead of just top students—and it made substantial investments in curriculum development, pre-service and in-service teacher education and informal science education, among others.

Then, in 2002, President Bush proposed the No Child Left Behind initiative to fundamentally reform elementary and secondary education. Among other things, this law requires assessments in reading and math for all students in grades 3–8 by the 2005–2006 school year and in science for students by the 2007–2008 school year. Students would be expected to make annual progress toward proficiency in each of these subjects. Failure to do so would result in the school's designation as "in need of improvement" and corrective actions, ranging from additional funds to school reconstitution. Other provisions call for all children to be taught by highly qualified teachers.

In response to national concerns regarding too many teachers teaching out of field, too few students taking advanced course work and too few schools offering challenging curricula, No Child Left Behind also called for the creation of a new Math and Science Partnership Program to unite the activities of higher education, school systems and business in support of improved math and science proficiency for K–12 students and teachers.

Ultimately, two programs were created. The first established a competitive, merit-based grant program at the National Science Foundation (NSF), as part of the NSF Authorization Act of 2002 (P.L. 107–368). This program awards grants to partnerships between institutions of higher education and one or more school districts to improve math and science education. Funds are used to develop innovative reform programs that, if proven successful, would be the key to large-scale reform at the State level. The second program was housed at the Department of Education and was created by the No Child Left Behind Act of 2001 (P.L. 107–110). Although similarly titled, the programs were created to be complementary to—not duplicative of—

each other. Specifically, NSF was to fund innovative programs to develop and test new models of education reform, thereby remedying a lack of knowledge about math and science research, while the Department of Education would broadly implement and disseminate new teaching materials, curricula and training programs. The FY 2004 omnibus appropriation would provide the Education and the NSF partnership programs with $150 million and $140 million respectively.

Undergraduate Programs

In addition to creating the Math and Science Partnership Program at NSF, the National Science Foundation Authorization Act sought to address the decline in the Nation's technical workforce and to improve undergraduate math and science education. Among other things, the bill established the Tech Talent Act (now known as the Science, Technology Engineering and Mathematics Technology Expansion Program, or STEP) to increase the number of U.S. students majoring in science, math, engineering and technology. Specifically, STEP provides funding and rewards to colleges and universities that develop creative and effective recruitment and retention strategies that bring more students into science, mathematics, and engineering programs. The FY 2004 appropriation for STEP is expected to be $24.85 million.

The bill also created the Robert Noyce Scholarship Program, which awards grants to colleges and universities to award scholarships to top math and science majors or minors in return for a commitment to teach at the elementary or secondary school level. The FY 2004 appropriation is expected to be $7.95 million.

6. Questions for Witnesses

Mr. Cassidy

- How can we attract, educate and retain the critical mass of talent necessary to keep the State of Georgia—and the country as a whole—at the forefront of research, development and ground-breaking advances in science and technology? In addition to providing a technically literate workforce, why is it important to improve public support and understanding of math and science?
- How do we avoid a disconnect between the jobs we want to keep in the U.S. and our workforce's ability to perform those jobs? How is the State of Georgia working with K–12 schools as well as colleges, universities and training programs to avoid that disconnect?
- How can we ensure that we provide sufficient opportunities to allow students and researchers, educators and employees to become and then remain current and competitive in our rapidly evolving world?

Dr. Ohme

- What do you feel is the single, most important step that the Federal Government should take to improve K–12 math and science education?
- How can we grow, educate, attract and retain the best and brightest scientists and engineering students? Based on the involvement you have had with math and science education programs at the U.S. Department of Education and the National Science Foundation as well as those in the State of Georgia, what are the most important and effective components of these programs?
- How can K–12-higher education partnerships reduce the need for remediation, promote interest in math and science education, and reduce the number of dropouts, especially for under-represented populations?

Ms. Purcell

- What sparked your interest in math and science? Was it a teacher or a class? Or was it something outside your formal education, like a trip to a science museum, a significant scientific event (a shuttle launch or a discovery), or interactions with a parent or relative?
- What made your math and science classes interesting to you? How could we help increase interest in math and science for other students?
- In thinking about the many different subjects you could study in college, why did you choose the way you did? Were you aware of the types of jobs that are available to students with a strong math or science background? What would you like to do with your degree after graduation?

Mr. McClure

- Based on the involvement you have had with math and science education programs at the U.S. Department of Education and the National Science Foundation as well as those in the State of Georgia, what are the most important and effective components of these programs?
- How can we spark a greater student interest in math and science education? What can we do to ensure that student interest in math and science does not wane as they progress through our formal system of education?
- What challenges do you face in improving student achievement in math and science education? How can parents, businesses, the community, and the government support you in your efforts to raise student proficiency in math and science?

Mr. Hill

- What is the overall state of math and science education in Georgia? Why is it important for all students to achieve proficiency in these subjects, as envisioned in No Child Left Behind?
- Based on the involvement you have had with math and science education programs at the U.S. Department of Education and the National Science Foundation as well as those in the State of Georgia, what are the most important and effective components of these programs?
- What have you learned about the ability—or the inability—of K–12-higher education partnerships, such as those created by No Child Left Behind, to reduce the need for remediation, to promote interest in math and science education, and to reduce the number of dropouts, especially for under-represented populations?

Mr. GINGREY. Good morning everybody. I would like to call the meeting of the House Science Committee, the Full Committee meeting to order.

We will begin the meeting with our presentation of the colors.

[Color guard.]

[Pledge of Allegiance.]

Mr. ARNSON. Thank you all for coming and joining us this morning. At this time, I would like to introduce Representative Phil Gingrey.

Mr. GINGREY. Thank you very much, Principal Arnson.

[Applause.]

Mr. GINGREY. It is great to be here today in my District at Campbell High School.

What I would like to do is just describe to you the format of what we're doing. I want you to know that we are going to—this is a formal field hearing of the full Committee on Science of the United States Congress and the written statements that are presented by our panelists and the questions and answers, all of that will be part of the permanent Congressional Record. So I want to say to the people that are here this morning, that are participating, make sure you put this date. I think today is—I should remember and know that today is January the 23rd because tomorrow my daughter is getting married and I know that is on January the 24th. But you put this date down in your Blackberry so you can tell your grandchildren one of these days to look it up in the Congressional Record, you were part of a Full Committee hearing of the Science Committee. So welcome one and all.

I hope everybody in attendance knows who I am. If you do not, I may be in a little bit of trouble come next November the 2nd. So I am not going to tell you anything about myself. But it is certainly a great honor for me to chair this Full Committee hearing of the Science Committee with one of my freshmen colleagues on the Committee, and that is the Honorable Representative Lincoln Davis. He is a Member of Congress from the great State of Tennessee, the Volunteer State. He is from a county that I did not know whether to pronounce Pall Mall or Pell Mell, Tennessee, but he reminded me that it was Pall Mall. So I was at least halfway in between and we finally got it right.

Representative Davis, like myself, was elected a year ago to the Congress. He is the former mayor of Byrdstown, Tennessee. So he, like me, kind of started locally. I think most of you know that I was a member of the Marietta City School Board. That was my first taste of politics, and I think Congressman Davis would agree with me that all politics eventually—it starts local and it ends local. I think we are very proud of that. He and I—I have to tell you all—you can figure it out later exactly what the age is, but we are about the same age. He has actually been married a little bit longer than I have. He and his wife Linda, I believe, have been married 40 years, and she was his high school sweetheart. Now, I want to tell you a little bit about Congressman Davis, and I do not know what the significance of this is. But his first name is Lincoln, her first name is Linda and they have three daughters, Lorissa, Lynn and Libby. Now, I think that is called a bit of an alliteration. And now with five grandchildren, Ashton, Alexia, Andrew, Austin and Adam, I will let Congressman Davis explain all of that to us.

He is a farmer and a builder and developer. He actually—his farmland was purchased from Alvin York, the great World War I hero whose name we all recognize. He has lived in Fentress County all of his life and is a hometown boy and a great member of the Congress.

I will tell you another thing about our committee. The Science Committee is fairly equally balanced between Republicans and Democrats. Of course, when you have the majority there is always at least one more Republican than Democrat. But it is a very unbiased, bipartisan committee. In fact, Congressman Davis' colleague from Tennessee, Representative Bart Gordon, has just been named Ranking Member of the Committee. So it is with a great deal of pleasure that I am here today having this committee hearing with my colleague from Tennessee, Representative Lincoln Davis. I will turn it over to him in just a minute for his opening remarks.

First of all, let me say thank you, Principal Arnson, for your warm welcome and Major Moyers and the Army Junior ROTC—I am very proud of you—for the presentation of our colors, and Chad Smith for leading us in the Pledge of Allegiance. I know his dad, who is here this morning, and a Council Member from the City of Smyrna, is very proud of Chad.

It is my pleasure to welcome all of you this morning to this very important House Science Committee hearing titled Fueling the High Tech Workforce with Math and Science Education. I know many of the students in attendance are AP math and science students, and possibly some International Baccalaureate, and we are very proud that you are with us this morning.

I am excited about holding the hearing in Cobb County, and again, Principal Arnson, I want to thank Campbell High School for so graciously hosting this event. And I want to thank our witnesses for being here to testify before the Committee. I look forward to hearing your insights and your opinions. Also, as I stated, welcome my colleague, Congressman Davis.

Today, we will examine various strategies underway in Georgia and nationally to improve student achievement and teacher performance in math and science education, and how a well educated science and technology workforce enhances job creation and economic vitality.

The importance of elementary, secondary and post secondary math and science education to Georgia and the Nation's high tech economy is apparent. Georgia's science and technology workforce is ranked 11th in the Nation and it is continuing to grow. Its biotechnology workforce is ranked ninth. The United States Department of Labor projects that new jobs requiring science, engineering and technical training will increase four times higher than the average job growth nationally. Clearly, workers require a solid academic foundation in science and math to succeed in this high tech workplace and to remain competitive with students from other nations in our global economy. Right now we are not. Studies have shown over the last several years that compared to other developed industrial nations we are behind. We are particularly behind in math and science.

Only two out of every 100 high school graduates will ever obtain an engineering or a technical degree. Let me repeat that. Only two out of every 100 high school graduates will ever obtain an engineering or technical degree. Consequently, only nine out of 1000 women and eight out of 1000 minorities will ever obtain an engineering degree. Worse, most of the graduating class in America's high schools are either not prepared or not sufficiently motivated to pursue advanced study in science, math, engineering or technology fields. According to the National Assessment of Educational Progress, fewer than $\frac{1}{3}$ of all United States students in grades 4, 8 and 12 performed at or above proficient levels in math and science, while $\frac{1}{3}$—fully $\frac{1}{3}$ performed below basic levels.

Tuesday night, in his State of the Union address, President Bush stressed the importance of promoting quality math and science education when he announced the Jobs for the 21st Century plan. Among other initiatives that will help better prepare workers for jobs in the new millennium, the plan calls for a $120 million increase for a mathematics and science partnership program. That program establishes partnerships between high schools and post secondary technical, vocational colleges and two-year colleges to increase achievement in both math and science for all secondary students.

While there are no quick fixes, we can take steps now to re-examine how teachers teach and students learn math and science. Failure to address our problems will impact Georgia's economic growth and consequently the economic welfare and scientific discovery of the Nation as a whole.

We will hear testimony this morning from witnesses with expertise across the broad spectrum of this issue. We'll hear from a student who plans to use the knowledge and education that she has obtained in math and science and pursue a career in medicine; a teacher who has dedicated his life to fueling students with a passion for science; an administrator that strives to implement the best policies for educating Georgia's students; a professor who seeks to meet the future challenges by encouraging and inspiring the very best in science, math and technology education for all students; and finally, a business leader who leverages Georgia's research capabilities into economic development results. I thank you and certainly look forward to hearing your testimony.

I would like now to introduce to you Congressman Lincoln Davis for his opening remarks. Congressman Davis.

[Applause.]

[The prepared statement of Mr. Gingrey follows:]

PREPARED STATEMENT OF REPRESENTATIVE PHIL GINGREY

Thank you, Principal Arnson, for your warm welcome, and Major Moyers, the Junior ROTC, for the presentation of our colors, pledge, and National Anthem.

It is my pleasure to welcome all of you this morning to this very important Science Research Subcommittee hearing, *"Fueling the High Tech Workforce With Math and Science Education."* I am excited about holding this hearing in Cobb County and want to thank Principal Arnson and Campbell High School for hosting this event. I want to thank our witnesses for being here to testify before the Committee, I look forward to hearing your insights and opinions. Also, I want to welcome my colleague, Congressman Lincoln Davis from Tennessee, to the great State of Georgia and thank him for attending this hearing.

Today, we will examine various strategies underway in Georgia and nationally to improve student achievement and teacher performance in math and science education, and how a well-educated science and technology workforce enhances job creation and economic vitality.

The importance of elementary, secondary, and post-secondary math and science education to Georgia and the Nation's high tech economy is apparent. Georgia's science and technology workforce is ranked 11th in the Nation and continues to grow, it's biotechnology workforce ranked 9th. The U.S. Department of Labor projects that new jobs requiring science, engineering, and technical training will increase four times higher than average job growth nationally. Clearly, workers require a solid academic foundation in science and math to succeed in this high tech workplace and to remain competitive with students from other nations in our global economy.

However, only two out of every one hundred high school graduates will ever obtain an engineering or technical degree. Consequently, only nine out of a thousand women and eight out of a thousand minorities will ever obtain an engineering degree. Worse, most of the graduating class in America's high schools are either not prepared or not sufficiently motivated to pursue advanced study in science, math, engineering, or technology fields. According to the National Assessment of Educational Progress, fewer than one-third of all U.S. students in grades four, eight, and twelve performed at or above proficient levels while a third performed below basic levels.

While there are no quick fixes, we can take steps now to re-examine how teachers teach and students learn math and science. Failure to address our problems will impact Georgia's economic growth and, consequently, the economic welfare and scientific discovery of the Nation as a whole.

We will hear testimony from witnesses with expertise across the broad spectrum of this issue. We'll hear from a student who plans to use the knowledge and education that she has obtained in math and science and pursue a career in medicine; a teacher who has dedicated his life to fueling students with a passion for science; an administrator that strives to implement the best policies for educating Georgia's students; a professor who seeks to meet the future challenges by encouraging and inspiring the best in science, math, and technology education for all students; and a business leader who leverages Georgia's research capabilities into economic development results. Thank you and I look forward to hearing your testimony.

Mr. Davis.

Mr. DAVIS. Congressman Gingrey, it is certainly good to be here in Georgia this morning. We drove down yesterday afternoon from Pall Mall to Jamestown and then traveled Highway 127 to 111 which connects the southern part of Tennessee to the northern part where I live. It is an Appalachian Highway. I live in the part of Tennessee that we call Appalachia, and often times instead of accepting the words that they call us, being a ridgerunner or a hillbilly or a redneck, we have coined a new phrase for those of us who live there called being an Appalachian-American.

[Laughter.]

Mr. DAVIS. We have southeasterners and northeasterners and midwesterners, so I assume if you live in the mountains of Tennessee or Georgia, and it is the Appalachian Mountains, then we have a heritage there that we should all be proud of. But included in that heritage is a heritage in many cases of a lack of a public education or of academic achievement, especially through the turn of the last century and through the early part of the 20th century. We are seeing changes being made now in each state, here in Georgia as well as in Tennessee and many southern states, to recognize that a good education brings about a good economy. I think because of our public education, America today probably has the best economy of any country, in my opinion, throughout civilization. Education has made a difference in all of us.

Thanks for having the hearing today, for allowing me to be a part, for being here.

Certainly I have had an opportunity to see two of my daughters married off and I have those five grandchildren and I am not sure exactly how the names came. Our first daughter, Lorissa, came as a store-bought name from a book. The rest of them, Mrs. Davis just liked them, so that is why we named them the names they have. And our three daughters live, not in the same hometown, so I am not sure why they started out with the A's.

How many children do you have?

Mr. GINGREY. We have—is my mic on? I think we have—I know we have——

[Laughter.]

Mr. GINGREY. —four children and three grandchildren.

[Laughter.]

Mr. DAVIS. I have you beat in the grandchildren line, as we call them back home, those little tricycle motors. We have you beat there, but we have three daughters. I commend you tomorrow on the wedding that will occur. Is that the last one?

Mr. GINGREY. That is the last one for awhile, yes.

[Laughter.]

Mr. DAVIS. I guess we can get down to business then. I want to thank you for inviting me. Certainly we are here today to discuss how to fuel the high tech pipeline, how to improve math and science education and how to promote better diversity among our math and science students, graduates and post graduates and faculty.

I want to welcome those who are witnesses today, the students, the teachers, the policy directors, administrators, all interested in the future outlook of math and science education.

We have two major concerns that we will discuss today and those who will give the testimony will allude to that. Performance of schools in preparing students for careers in science and technology being one of those.

The National Education Association recently released in the fall of 2003 expenditures for students in public K through 12 schools. Georgia ranked 18th, spending over $8000 per student, a 5.3 percent increase from 2002. I am from Tennessee. Sadly we ranked number 45 at $6048 expenditure per student per year, reflecting only a 1.7 percent increase last year. Over 40 percent of the freshmen at public two-year colleges and 13 percent of private four-year colleges are enrolled in remedial courses. Approximately 35 percent of the companies provide remedial math education for their employees. Think about that a moment. They are hiring someone that supposedly was trained in a certain discipline to work in a company and almost 35 percent of those in math have to have remedial courses. This indicates that students are not being sufficiently prepared in science and math.

Some serious demographics. This week Dr. Donald Nelson of MIT released results from a survey of the top 50 departments in each of 14 science and engineering disciplines as ranked by the National Science Foundation according to research funds expended. This comprehensive analysis of tenured and tenure track faculty shows that females and minorities are significantly under-represented. There are few tenured and tenure track women faculty in these departments and research universities even though a growing number of women are completing with their Ph.D.s.

Under-represented minority faculty. Women are almost nonexistent in science and engineering departments at research universities. In the computer science department surveys, there were zero black, Hispanic or Native Americans tenured or tenure track women faculty. The percentage of women who earn Bachelor degrees in science and engineering continues to increase, but they are rapidly finding themselves without female faculty role models. There are few female professors in science and engineering. The percentage of women among full professors range from only 3 to 15 percent.

I live in an area that is close to Tennessee Tech. The Georgia Tech folks probably recognize that school as being one of the better technical schools in the southeast. Georgia Tech, most here in this area would say, probably ranks number one. But certainly Tennessee Tech, we would rank very close to that, especially in engineering and in the sciences. We realize in our area, as you realize here at Georgia Tech, that without the technical training it will be extremely difficult to be competitive in what we will be calling a high tech workforce in the future.

A math and science education is important to me. It is important to my constituents in Tennessee in the Fourth District and it is extremely important to our nation as a whole if we are going to continue to remain competitive in the world. It has been said that education lies at the heart of this Administration's Invest in America's Future. The President is committed to education. How well our nation prospers in the years ahead will depend in part on how well we develop scientific and technical talent in our children.

For fiscal year 2002 the budget of the National Institutes of Health, our nation's primary funding mechanism of academic biomedical research, was increased by 14 percent; for fiscal year 2004 however, there will be likely only about a three to four percent increase, in many cases maybe bringing biomedical programs to a screeching halt. The math and physical sciences are even in more dire straits. Without financial backing, the potential for growth in these areas is limited.

How can we do more with less money and what is the solution? Maybe we will hear that today. I know that much effort is underway in Georgia and throughout the Nation to improve K through 12 science and math education. I hope today the hearings will highlight some of these efforts and will suggest ways to learn from and expand the most promising ideals and approaches to education reform.

Again, I congratulate you, Chairman Gingrey, for calling this hearing because there are few subjects of greater importance and consideration of this subcommittee. We are fortunate to have witnesses here today who have a broad range of experience and talent. I certainly look forward to your testimony and your discussion.

I want to congratulate this high school—I see you are four percent—within the top four percent in the Nation. I represent Campbell County, so I feel at home. Livingston, Tennessee is on the way to where I catch the plane to Nashville. So I feel like I am at home in Livingston, Tennessee or in Campbell County when I see these names.

Thank you.

Mr. GINGREY. Congressman Davis, thank you very much.

[Applause.]

Mr. GINGREY. You know, in my opening remarks I commented that we have a very bipartisan committee, and I want to say one other thing. Those who might think that Republicans have a corner on traditional family values obviously have not met Congressman Lincoln Davis from Tennessee, who has been married, as I said earlier, to his childhood sweetheart Linda for 40 years. He's got three children and five grandchildren and I think that's a pretty darned good record. So this morning I want to give Congressman Davis a little memento from the great State of Georgia. This peach, Congressman Davis, I know he might prefer a tobacco leaf.

[Applause.]

Mr. DAVIS. I can assure you as a youngster growing up, the farm folks would have an old pickup truck or a ton and a half truck—that is not a real heavy truck. It is not a tractor and trailer. They would come down here and buy peaches and then barter them out to the neighbors. The Georgia peach along about the first of August—the Alberta I think is what they called them—was the best freestone peach you could find in the world. So thank you for that.

Mr. GINGREY. Thank you again, Congressman Davis.

We will go ahead now—and I want to introduce to you our five panelists who will be giving their testimony. Once again, I remind all that their written remarks will be part of the permanent Congressional Record of this full Science Committee hearing.

First of all, I want to introduce to you Ms. Rachel Purcell, who obviously needs no introduction to the Campbell Spartans. She is the valedictorian of the senior class and hopes to pursue a career in veterinary medicine.

Next is Mr. Randy McClure. Again, Randy here at Campbell needs no introduction. He is a teacher, and actually more than just a teacher, the Chair of the Department of Science at Campbell High School, which, by the way, has the prestigious International Baccalaureate Program, the most rigorous academic program in the Nation, if not the world, as it is an international program. I think I am correct in saying this: We have that program also at Marietta High School as part of that system. This is the only venue of maybe 14 high schools in the Cobb County system that has the International Baccalaureate Program. I know teachers like Mr. McClure are very proud of that fact.

Mr. Martez Hill is the Policy director for the Georgia Department of Education, working very, very closely with our State School Superintendent Kathy Cox. Prior to coming to the Department Mr. Hill worked as an analyst in the Governor's Office of Planning and Budget. I guess he decided that that was a little rough these last two years and maybe the work with the Department of Education could be a little more fulfilling. I know it has been a tough time not only in the State of Georgia with the budget crunch but everywhere else in the Nation. He received his Bachelors degree in political science and his masters degree in public policy from prestigious Emory University.

And then Dr. Paul Ohme is the Director for the Center for Education in Science, Mathematics and Computing—the acronym is CEISMC—at my alma mater, Georgia Institute of Technology. Lincoln, I should have brought you a hat. Prior to joining CEISMC, Dr. Ohme served as the Associate Vice President for Academic Affairs and the head of the Department of Computer Science at Northwestern Louisiana University. Dr. Ohme also taught mathematics and computer science at various colleges and universities, including—and I know Congressman Davis is not going to want to hear this—Clemson. Did anybody watch the Peach Bowl?

Mr. DAVIS. I did not.

[Laughter.]

Mr. GINGREY. Congressman Davis said he did not.

[Laughter.]

Mr. GINGREY. He wants to know when is it going to be played.

[Laughter.]

Mr. GINGREY. Clemson, Mississippi, Franklin and Marshall.

And then finally Mr. Michael Cassidy, the President of the Georgia Research Alliance. Before joining the Alliance Mr. Cassidy managed the Advanced Technology Development Center, ATDC, based at again, Georgia Institute of Technology, one of the Nation's oldest technology incubators. He also worked for IBM where he held various staff and management positions. In addition to his work at the Alliance, Mr. Cassidy consults with several states on issues of science and technology policy, and he represents Georgia on the Southern Technology Council and the Southern Governors' Association Advisory Committee on research, development and technology.

We have a great list of participants on this committee and I look forward to their testimony. We will start with Ms. Rachel Purcell. Rachel.

[Applause.]

STATEMENT OF RACHEL PURCELL, VALEDICTORIAN, CLASS OF 2004, CAMPBELL HIGH SCHOOL, SMYRNA, GEORGIA

Ms. PURCELL. Mr. Chairman and esteemed Members of the Committee, I would like to thank you for allowing me to speak today. My name is Rachel Purcell and I am a senior in the International Baccalaureate Program here at Campbell High School. I have attended school in the Cobb County School District since kindergarten. The IB program is a magnet school and pulls from all of Cobb County, however, I currently reside in the Campbell High School District.

I have always been a curious individual and math and science have provided a means with which to satisfy my curiosity. The person who sparked my interest in both math and science was my fifth grade teacher. That year, I began to look forward to the afternoon time that was designated for science. In this class, we were expected to create many projects, including a wind-powered model car, an invention of our own design that we could actually use in our daily lives; and a task that I spent the majority of the year dreading, we dissected a cow's eye.

Looking back on these and other various projects which were completed at a time when lab write-ups and data charts were not necessary, I realize that I truly enjoyed the exposure to exploring the world around me. I became more interested in how and why things are the way they are because I was given an opportunity early in life to do more than read a science textbook and actually have some hands on experience being a scientist. I believe that this early opportunity to explore, without the complications of a larger high school class or the grade pressure of GPAs, led me to enjoy science at a younger age and that my positive attitude toward it has continued to affect my high school endeavors.

As I entered high school I was already on an advanced math track, having taken Algebra 1 and geometry before ninth grade. This advancement kept me interested and made it easier for me to reach the more advanced levels of math offered in my school while still only taking one semester of math a year. In my science curriculum, I was given the opportunity to take biology, physics and chemistry before I entered my junior year as part of my enrollment in the International Baccalaureate Program. Having a basic background in these three areas has made each successive science class easier and more enjoyable because the curriculums inevitably overlapped. These classes also gave me enough exposure to all three areas of science to allow me to make an educated decision when it was time to choose the area I would concentrate on in my junior and senior years of the IB program.

I found all these classes, both math and science, to be most enjoyable when I learned something and was then shown where the principle or concept affected my everyday life. I also found that open-ended labs, a standard part of the IB curriculum, in which we design and plan our own experiments, teach me more than those which are dictated by a teacher. Although they are generally more work for me as a student, I find them more enjoyable and satisfying because I feel that I have truly accomplished something when I am able to draw conclusions from my work.

In considering my future endeavors and career plans, I am not entirely sure what I want to pursue. I am currently considering a career in veterinary medicine. My interest in this area arises not only from the fact that I have always loved animals, but also from the fact that I feel medicine is one of the most practical and least abstract applications of my scientific knowledge. In the medical field, I will be able to use my strong scientific and mathematical background and also pursue a career that allows me to interact with and directly improve the lives of other people. The immediate and concrete applications of medical knowledge make it more attractive, applicable and interesting to me. However, even if my career plans change as I move through college, having a basis in all three major sciences at a high school level and having taken advanced levels of both biology and physics will provide a solid background for whatever I choose to do.

In conclusion, I feel that my own interest in math and science exists because I was exposed to them in a hands-on way as a younger child, and that having a basic exposure to more than one type of science has contributed to my success at more advanced levels. I believe that interest in the more advanced math and science classes offered in high school and college can be generated and augmented by exposing younger kids to the more enjoyable aspects of both math and science.

Thank you.

[Applause.]

[The prepared statement of Ms. Purcell follows:]

PREPARED STATEMENT OF RACHEL PURCELL

Mr. Chairman and esteemed Members of the Committee, I would like to thank you for allowing me to speak today. My name is Rachel Purcell and I am a senior in the International Baccalaureate Program here at Campbell High School. I have attended school in the Cobb County School District since kindergarten. The IB program is a magnet school and pulls from all of Cobb County, however, I currently reside in the Campbell High School district.

I have always been a curious individual and math and science have provided a means with which to satisfy my curiosity. The person who sparked my interest in both math and science was my fifth grade teacher. That year, I began to look forward to the afternoon time that was designated for science. In this class, we were expected to create many projects, including a wind powered model car, an invention of our own design that we could actually use in our daily lives, and a task that I spent the majority of the year dreading: we dissected a cow's eye.

Looking back on these and other various projects, which were completed at a time when lab write-ups and data charts were not necessary, I realize that I truly enjoyed the exposure to exploring the world around me. I became more interested in how and why things are the way they are because I was given an opportunity early in life to do more than read a science textbook and actually have some hands on experience being a "scientist." I believe that this early opportunity to explore, without the complications of a larger high school class or the grade pressure of GPAs, led me to enjoy science at a younger age and that my positive attitude toward it has continued to effect my high school endeavors.

As I entered high school I was already on an advanced math track, having taken Algebra I and Geometry before ninth grade. This advancement kept me interested and made it easier for me to reach the more advanced levels of math offered in my school while still only take one semester of math a year. In my science curriculum, I was given the opportunity to take biology, physics, and chemistry before I entered my junior year as part of my enrollment in the International Baccalaureate Program. Having a basic background in these three areas has made each successive science class easier and more enjoyable because the curriculums inevitably overlapped. These classes also gave me enough exposure to all three areas of science to allow me to make an educated decision when it was time to choose the area I would concentrate on in my junior and senior years of the IB program.

I found all these classes, both math and science, to be most enjoyable when I learned something and was then shown where the principle or concept affected my everyday life. I also found that open-ended labs, a standard part of the IB curriculum, in which we design and plan our own experiments, teach me more than those which are dictated by a teacher. Although they are generally more work for me as a student, I find them more enjoyable and satisfying because I feel that I have truly accomplished something when I am able to draw conclusions from my work.

In considering my future endeavors and career plans, I am not entirely sure what I want to pursue. I am currently considering a career in veterinary medicine. My interest in this area arises not only from the fact that I have always loved animals but also from the fact that I feel medicine is one of the most practical and least abstract applications of my scientific knowledge. In the medical field, I will be able to use my strong scientific and mathematical background and also pursue a career that allows me to interact with and directly improve the lives of other people. The immediate and concrete applications of medical knowledge make it more attractive, applicable, and interesting to me. However, even if my career plans change as I move through college, having a basis in all three major sciences at a high school level, and having taken advanced levels of both biology and physics will provide a solid background for whatever I choose to do.

In conclusion, I feel that my own interest in math and science exists because I was exposed to them in a hands-on way as a younger child, and that having a basic exposure to more than one type of science has contributed to my success at more advanced levels. I believe that interest in the more advanced math and science classes offered in high school and college can be generated and augmented by exposing younger kids to the more enjoyable aspects of both math and science.

BIOGRAPHY FOR RACHEL PURCHELL

Rachel Purcell is currently a senior in the International Baccalaureate Program at Campbell High School in Smyrna, Georgia. She resides in the Campbell High School district and attended King Springs Elementary School and Griffin Middle School before moving on to Campbell. Rachel is currently ranked to graduate as valedictorian of the senior class and is a semi-finalist in the National Merit Scholarship.

Throughout high school Rachel has participated in various activities. This year she was co-captain of Campbell's Varsity Slow-pitch Softball team and is currently co-president of her church's eighty-member youth choir. She is an active member of her school's drama club and theatre productions. Rachel also enjoys playing the piano and has been certified by the state level piano guild.

January 29, 2004

The Honorable Sherwood Boehlert
Chairman, Science Committee
2320 Rayburn Office Building
Washington, DC 20515

Dear Congressman Boehlert:

Thank you for the invitation to testify before the U.S. House of Representatives Committee on Science on January 23rd for the hearing entitled *Fueling the High Tech Workforce with Math and Science Education*. In accordance with the Rules Governing Testimony, this letter serves as formal notice that I received no federal funding directly supporting the subject matter on which I testified, in the current fiscal year or either of the two proceeding fiscal years.

Sincerely,

Rachel Purcell

Rachel Purcell

Mr. GINGREY. Thank you, Rachel.

We will next hear from Mr. Randy McClure.

STATEMENT OF RANDY O. MCCLURE, TEACHER AND DEPARTMENT CHAIR FOR SCIENCE, CAMPBELL HIGH SCHOOL, SMYRNA, GEORGIA

Mr. MCCLURE. Mr. Chairman, based on my involvement with science education over the past 18 years at the State level, I believe that we have not quite had the opportunity to really follow science projects to their end. In science we develop laws and concepts that serve as our guiding tenets based on our ability to test things and get data from multiple trials in various places under the same conditions. Unfortunately, we do not always get the chance to produce data or even accumulate enough data to really see what impact our efforts have had.

I believe I can say with all confidence that no true secondary science teacher minds at all being asked to deliver the constantly changing information that is being developed in the many fields of science. Especially included in that idea is the fact that many teachers love the opportunities presented by the infusion of new technologies that ought to allow greater achievement by eliminating some menial aspects of science discovery. For example, it is certainly more beneficial for a chemistry student working on determining the pH levels of materials, to be able to use probes that can make those determinations to two significant digits rather than relying on indicator paper to turn pink or blue and then guessing about the actual pH level. The students who can use the probes would be light years ahead of those still using indicator paper.

Some of the reasons for stating such marked differences in techniques to achieve similar opportunities to collect data are as follows: Probe data collection can be pinpointed and graphed by that probe. That information can then be transferred into a PowerPoint presentation so that students could compare results and observe data changes while making incredible analyses of their data. Those students with the indicator paper would be unable to get to the deeper inquiry into the laboratory assignment because of the inflexibility of the materials employed.

Herein lies the great dichotomy of science education and in particular how it is affected by technology. Until there are no areas where students are still relying on outdated methods in science classes across our state and country, the potential for some of our brightest and most gifted future scientists, engineers and those who would aspire to high-tech careers will be at best hindered and in many cases simply stymied because of the lack of access to the latest materials.

Teachers must be able to constantly receive training in methods that are cutting edge. The roadblocks to this training should be eliminated. It should be easy for certified teachers to gain access to top notch universities during summers or during the school year to constantly make themselves aware of the cutting edge applications of the concepts taught in some basic science classes. From the prototype glasses that can allow one to translate one language into another by simply putting on the glasses to the pill that cannot only alert parents of pregnancy, but allow them to know if their offspring will be predisposed to over 3000 diseases or disorders, these types of discoveries and more must be made available to today's science teacher and the technology commensurate with these developments in order to make an indelible impact on aspiring scientific students.

We can spark greater interest in science by not allowing the materials we use to be outdated by the fast developing fields that the students are being introduced to. Again, the analogy would serve well if we considered students eager to learn about boating who were introduced to boating through different vehicles. One group receives an old rowboat, while another group receives the latest inboard motorboat with depth finders and weather monitors. Both could get to certain destinations, but surely those who have the advantages of more sophisticated instruments could advance further and quicker to the point of interest. Also, since some of the menial navigation duties could be eliminated and the mode of operation by powering the boat rather than oars, the students with the updated boat would be able to make greater observations during the course of their trip.

From the beginning of kindergarten, students come to us with inquisitive minds. What we do with them makes all the difference in the world. For example, at Russell Elementary here in Cobb County, elementary students work all year long with computers to meet their annual NASA simulated launch date in May. Many hours after school and ongoing assignments are completed so students can track the path of their space shuttle, choose alternate launch sites if the weather is bad, monitor every aspect of the shuttle's security and maintenance during the trip and determine where it lands upon its return. This happens in the fifth grade and there is a great partnership between the community, school, staff and parents. But if your child does not attend Russell Elementary or have Mr. Chris Laster as their science teacher, he or she may not have that wonderfully inspiring experience.

As students leave elementary schools and go on to middle schools and high schools, there should be some comparable programs that allow for exciting experiences that will cause them to want to be involved in more science. Again, depending on where they are and what they are exposed to, this may or may not happen.

Perhaps we should allow our classrooms to become more inquiry based and less test oriented so that many of our tried and true best practices could take effect and give us an opportunity to collect some data to really examine our results. No one minds accountability, but perhaps we have moved so much to testing that we have left no real time for creating atmospheres that will inspire and generate interest in science fields.

The challenges of teaching science are complex. First, due to the advances that are vastly changing the field of science the curriculum has to be more accountable in that it addresses what we want students to know and eliminates trivial pursuits posing as standardized tests with little relevance to the emerging high-tech world.

Secondly, students must be given the opportunity to learn without the constant impending threat of evaluation that covers too much and are not markers of accountability but instead simply indicate a lack of continuity between theoretical and practical applications of science education. Also, parents must be mentioned in the equation for success in creating science and high-tech career candidates for our economy. Teachers are constantly reminded of all their shortcomings but rarely does anyone challenge parents to do their part in helping to make sure that their child is successful in the science world.

As a student at Morehouse College, when I found myself stuck with problems in my organic chemistry classes or advanced biochemistry classes, I would call home to my great-grandmother, who raised me, for help, and she was able to give me what I needed to complete my task. She only had a seventh grade education, yet she saw to it that my three younger brothers and I not only attended college but graduated with three of the four us being in science and technology related fields. Sometimes parents shy away because they may be unfamiliar or uncomfortable with technological advances. As a teacher and as living proof, I would like for someone to really hold parents accountable in a nonvoting type way so that they realize the real significance of their presence in their child's science education. Even if they have to learn some things with their child, it would be important for them to make that effort over and over again. Perhaps schools will also have to have science classes for parents to make sure that the message gets across. Businesses, the community and our government could really help in that regard. Also, if those three groups would make direct contact with science classrooms so that the red tape that sometimes hinders great ideas could be eliminated, we could make tremendous strides toward progress.

Finally, in closing, Mr. Chairman, I would respectfully request that you remember that every time new marching orders are passed down from our leaders, there are some teachers in science education who enact those orders, even if they are in the second or third years of previous marching orders. Not unlike the brave men and women of our country who are sworn to protect our flag and our way of life, there are those, I believe, who have been called to deliver science instruction to the students of our country. They attempt to complete this task regardless of all the variables that could affect their ability to complete that task. While we would all agree, and most work constantly to do just that, we do need those sending down our new marching orders to know that we need to have the broad support of parents, businesses, the many communities and yes, our government if we are to continue to be the world's envy of technology and its future development.

[The prepared statement of Mr. McClure follows:]

PREPARED STATEMENT OF RANDY O. MCCLURE

Mr. Chairman,

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BIOGRAPHY FOR RANDY O. MCCLURE

Teacher and Science Department Chair at Campbell High School

18-year teacher

1995–1996—Teacher of the Year at Campbell High School

1995–1996—Coach of the Year—Basketball, *Marietta Daily Journal*

1990—Martin Luther King, Jr. Humanitarian Award recipient

1995–1996–1997—*Who's Who Among American High School Teachers*

1996 Olympic Torch Bearer

March 11, 2004

The Honorable Sherwood Boehlert
Chairman, Science Committee
2320 Rayburn Office Building
Washington, DC 20515

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Thank you for the invitation to testify before the U.S. House of Representatives Committee on Science on January 23rd for the hearing entitled *Fueling the High Tech Workforce with Math and Science Education*. In accordance with the Rules Governing Testimony, this letter serves as formal notice that I received no federal funding directly supporting the subject matter on which I testified, in the current fiscal year or either of the two proceeding fiscal years.

Sincerely,

Randy O. McClure

Randy O. McClure
Science Department Head

Mr. GINGREY. Thank you, Mr. McClure.

[Applause.]

Mr. GINGREY. We will now hear from Mr. Martez Hill.

STATEMENT OF J. MARTEZ HILL, POLICY DIRECTOR, GEORGIA DEPARTMENT OF EDUCATION

Mr. HILL. Mr. Chairman, on behalf of the State Superintendent of Schools, Kathy Cox, first I want to thank you for the opportunity to testify to the Committee on Science today. I also want to thank you and the other members of the Committee for your continued support for science and math education through the National Science Foundation. My name is Martez Hill. Currently, I serve as the Policy Director for the Georgia Department of Education.

Earlier this month, Superintendent Cox joined President Bush and Secretary Paige in Knoxville, Tennessee to commemorate the second anniversary of the No Child Left Behind Act of 2001, also known as NCLB. Superintendent Cox was the sole chief state school officer invited to take part in the landmark event. Superintendent Cox truly believes in the underlying principles of the NCLB legislation and the goal of ensuring all students are performing at grade level in reading and math by 2013 and 2014.

Even prior to the enactment of No Child Left Behind, Georgia was a leader in building a foundation of accountability to improve student achievement. Georgia law required criterion referenced assessments for math, science, reading/language arts and social studies embraced [in grades] three through eight and district report cards, disaggregation of student data by subgroup, consequences and rewards and incentives to raise teacher quality through programs like National Board Certification.

Georgia has diligently moved to raise student achievement levels across the curriculum for several years. In part, the state was spurred by results from assessments from the 2000 National Assessment of Educational Progress which showed that our students were not learning to their full potential in both science and mathematics. Georgia's economy is inextricably linked to the education of its citizenry and the quality of its schools, so the continued growth of Georgia's high tech job market and its overall economy is linked to the state's efforts to lead the Nation in improving student achievement.

With that in mind, let me briefly highlight three state pre K through 16 initiatives involving partnerships between the Georgia Department of Education, the Board of Regents and local school systems which are designed to increase math and science achievement. I also want to talk about a research study designed to measure No Child Left Behind's impact on math and science achievement. These partnerships and research study align with Superintendent Cox's efforts to strengthen Georgia's performance standards that will drive both instruction and assessment for Georgia's teachers and students.

As we work to lead the Nation in improving student achievement, the Georgia Performance Standards will be the foundation upon which we build. Our teachers have long needed a published and usable document that establishes high standards, maintains clear expectations and provides specific guidelines for facilitating student learning at a deeper level than possible under the old Quality Core Curriculum. We have drawn on national and international best practices to produce a curriculum that will enable our schools and students to achieve at levels that will place Georgia not just at the top of the southeast, but at the top of the Nation and the world. The number of math and science contents standards has been trimmed down to give students the opportunity to achieve mathematical and scientific literacy through deeper study. With fewer topics, teachers will be able to go deeper into appropriate material and increase the overall rigor and expectation of each grade level and course. In the past, there has been too much material for students to have the opportunity to master key concepts.

The Georgia Performance Standards, as well as explanatory videos and presentations describing the major changes in each content area are available at the Georgia Department of Education's website at www.doe.k12.ga.us. I will say that again, www.doe.k12.ga.us. We have asked the public to provide feedback on the curriculum. We will use the comments as we make final revisions to the curriculum document which will be presented to the State Board of Education for approval in May and implemented this fall.

In Georgia the mathematics and science partnership activities support partnerships between high-need K–12 schools and departments of engineering, mathematics and science in institutions of higher education and other stakeholders. MSP activities—mathematics and science partnership activities—are aligned with the State's performance standards for science and math and are classroom focused in order to produce a measurable improvement in student academic achievement in mathematics and science. One of the most important indicators of student achievement, of course, is teacher quality. To lead the Nation again in improving student achievement, each classroom must have an effective teacher. Toward this end, Georgia's math and science partnership activities are focused on recruiting, training and retaining the best and brightest math and science teachers at the middle school level.

In September 2003, the Georgia Partnership for Reform in Science and Math, also known as PRISM, was awarded a $34.6 million grant from the National Science Foundation. PRISM's overarching goal is to raise academic achievement and close the performance gaps among Georgia's students in science and math. PRISM will directly impact 170,000 students and more than 10,000 teachers in Georgia. In addition, the project will involve over 550 college and university faculty from the University System of Georgia institutions. Similar to the Math and Science Partnership program, PRISM supports professional learning activities for pre K through 12 and higher education faculty and provides a mechanism for P–16 collaboration in the revision of Georgia's performance standards in math and science.

Georgia has agreed to participate in a four-year study beginning in this current school year, 2003/2004, by RAND, a not-for-profit public policy research organization. The RAND study focuses on the impact of accountability on mathematics and science instruction and student achievement in elementary and middle schools. This research project is funded by the National Science Foundation and will include interviews, surveys and case studies from 25 local school systems across the State. At the end of each year, RAND will provide a summative report of its findings to the State and participating local school systems and a final report at the end of the project. Georgia is one of only three states included in this national research project. We believe the results will be important to educators in Georgia.

No Child Left Behind, as you all know, requires a minimum 95 percent participation rate on state assessments for all subgroups enrolled in a school and school system in order for the school and the system to meet adequate yearly progress. Many of Georgia's high schools failed to make AYP, adequate yearly progress, in 2003 because of poor student attendance during the administration of the state assessments. The Georgia Department of Education has created a student attendance task force comprised of representatives from local school systems, schools, state and juvenile court systems, local law enforcement, family and children agencies and other community stakeholders to develop state and local programs and processes to prevent and stop truancy and student absenteeism.

The convergence of the rewriting of the State's curriculum, the Math and Science Partnership, the PRISM grant, the RAND study of Georgia's implementation of No Child Left Behind and the work of the student attendance task force will create substantive improvement in Georgia's math and science education.

Again, thank you for the opportunity to testify today. I will be more than happy to answer questions.

[Applause.]

[The prepared statement of Mr. Hill follows:]

PREPARED STATEMENT OF J. MARTEZ HILL

Mr. Chairman, on behalf of State Superintendent of Schools Kathy Cox, first I want to thank you for the opportunity to testify to the Committee on Science today. I also want to thank you and the other Members of the Committee for your continued support for science and math education funding through the National Science Foundation. My name is Martez Hill. Currently, I serve as the Policy Director for the Georgia Department of Education.

Earlier this month, Superintendent Cox joined President Bush and Secretary Paige in Knoxville, Tennessee to commemorate the second anniversary of the No Child Left Behind Act of 2001 (NCLB). Superintendent Cox was the sole chief state school officer invited to take part in the landmark event. Superintendent Cox truly believes in the underlying principles of the legislation and the goal of ensuring all students are performing at grade level in reading and math by 2013–2014.

Even prior to the enactment of NCLB, Georgia was a leader in building a foundation of accountability to improve student achievement. Georgia law required criterion reference assessments for math, science, reading/language arts, and social studies in grades 3–8, State and district report cards, the disaggregation of student data by subgroup, consequences and rewards, and incentives to raise teacher quality through programs like National Board Certification.

Georgia has diligently moved to raise student achievement levels across the curriculum for several years. In part, the State was spurred by results from assessments like the 2000 National Assessment of Educational Progress (NAEP) which showed that our students were not learning to their full potential in both science and mathematics. Georgia's economy is inextricably linked to the education of its citizenry and the quality of its schools, so the continued growth of Georgia's high tech job market and its overall economy is linked to the State's efforts to lead the Nation in improving student achievement.

Georgia's P–16 Initiatives

With that in mind, let me briefly highlight three state P–16 initiatives involving partnerships between the Georgia Department of Education, the Board of Regents, and local school systems designed to increase math and science achievement and a research study designed to measure NCLB's impact on math and science achievement. These partnerships and research study align with and support Superintendent Cox's efforts to strengthen Georgia Performance Standards that will drive both instruction and assessment for Georgia's teachers and students.

World Class Performance Standards

As we work to lead the Nation in improving student achievement, the Georgia Performance Standards will be the foundation upon which we build. Our teachers have long needed a published and usable document that establishes high standards, maintains clear expectations, and provides specific guidelines for facilitating student learning at a deeper level than possible under the old Quality Core Curriculum. We have drawn on national and international best practices to produce a curriculum that will enable our schools and students to achieve at levels that will place Georgia not just at the top of the southeast, but at the top of the Nation and the world.

The number of math and science content standards have been trimmed down to give students the opportunity to achieve mathematical and scientific literacy through deeper study. With fewer topics, teachers will be able to go deeper in appropriate material and increase the overall rigor and expectation of each grade level and course. In the past, there has been too much material for students to have the opportunity to master key concepts.

The Georgia Performance Standards, as well as explanatory videos and streaming webcast presentations describing the major changes in each content area, are available at the Georgia Department of Education's website www.doe.k12.ga.us. We have asked the public to provide feedback on the curriculum. We will use the comments as we make final revisions to the document, which will be presented to the State Board of Education for approval in May and implemented this fall.

Mathematics and Science Partnership Program

In Georgia, the Mathematics and Science Partnership Program (MSP) activities support partnerships between high-need K–12 schools and departments of engineering, mathematics, and science in institutions of higher education and other stakeholders. MSP activities are aligned with the State's performance standards for science and math and are classroom focused, in order to produce a measurable improvement in student academic achievement in mathematics and science. One of the most important indicators of student achievement is teacher quality. To lead the Nation in improving student achievement, each classroom must have an effective teacher. Towards this end, Georgia's MSP activities focus on recruiting, training, and retaining the best and brightest math and science teachers at the middle school level.

Partnership for Reform in Science and Mathematics

In September of 2003, the Georgia Partnership for Reform in Science and Mathematics (PRISM) was awarded a $34.6 million grant from the National Science Foundation (NSF). PRISM's overarching goal is to raise achievement levels and close the performance gaps among Georgia's students in science and mathematics. PRISM will directly impact 170,000 students and more than 10,000 teachers in Georgia. In addition, the project will involve over 550 college and university faculty from the partner University System of Georgia institutions. Similar to the Math and Science Partnership program, PRISM supports professional learning activities for P–12 and higher education faculty and provides a mechanism for P–16 collaboration in the revision of Georgia's Performance Standards in math and science.

RAND Study of Standards-Based Accountability

Georgia has agreed to participate in a four-year study beginning in school year 2003–2004 by RAND, a not-for-profit public policy research organization. The RAND study focuses on the impact of accountability on mathematics and science instruction and student achievement in elementary and middle schools. This research project is funded by the National Science Foundation and will include interviews, surveys, and case studies from 25 local school systems across the State. At the end of each year, RAND will provide a summative report of its findings to the State and the participating local school systems, and a final report at the end of the project. Georgia is one of only three states included in this national research project, and we believe the results will be important to educators in Georgia.

Reducing Dropouts

NCLB requires a minimum 95 percent participation rate on State assessments for all subgroups enrolled in a school and school system in order for the school and system to met Adequate Yearly Progress (AYP). Many of Georgia's high schools failed to make AYP in 2003 because of poor student attendance during the administration of the State assessments. The Georgia Department of Education has created a Student Attendance Task Force comprised of representatives from local school systems, schools, the State juvenile court system, local law enforcement, family and children agencies, and other community stakeholders to develop State and local programs and processes to stop and prevent truancy and student absenteeism.

The convergence of the rewriting of the State's curriculum, the Math and Science Partnership, the PRISM grant, RAND's study of Georgia's implementation of NCLB, and the work of the Student Attendance task force will create substantive improvement in Georgia's math and science education.

Again, thank you for the opportunity to testify today. I would be pleased to answer any questions you may have.

BIOGRAPHY FOR J. MARTEZ HILL

J. Martez Hill is a native Georgian and graduated from Emory University in 1993 with a Bachelor of Arts in Political Science. He graduated from Duke University in 1996 with a Master of Public Policy. From 1997 to 2003, he worked as an analyst in the Georgia Governor's Office of Planning and Budget. In January 2003, Georgia

State Superintendent of Schools Kathy Cox hired Mr. Hill as the Policy Director for the Georgia Department of Education.

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January 28, 2004

The Honorable Sherwood Boehlert
Chairman, Science Committee
2320 Rayburn Office Building
Washington, DC 20515

Dear Congressman Boehlert:

Thank you for the invitation to testify before the U.S. House of Representatives Committee on Science on January 23rd for the hearing entitled *Fueling the High Tech Workforce with Math and Science Education*. In accordance with the Rules Governing Testimony, this letter serves as formal notice of the Federal funding I currently receive in support of my research.

I received no federal funding directly supporting the subject matter on which I testified, in the current fiscal year or either of the two proceeding fiscal years.

Sincerely,

J. Martez Hill

J. Martez Hill
Policy Director

An Equal Opportunity Employer

Mr. GINGREY. Thank you, Mr. Hill.
Next we will hear from Dr. Ohme.

STATEMENT OF DR. PAUL OHME, DIRECTOR, CENTER FOR EDUCATION INTEGRATING SCIENCE, MATHEMATICS AND COMPUTING (CEISMC), GEORGIA INSTITUTE OF TECHNOLOGY

Dr. OHME. Honorable Representatives Gingrey and Davis and members of the staff and other citizens present, thank you for the opportunity to appear before you to address how elementary, secondary and post secondary mathematics and science education is critical to innovative scientific research and to our high tech economy.

It is my premise that the single most important step that the Federal Government should take to improve K–12 mathematics and science is to create and support an unequivocal expectation that all children can and will learn mathematics and science at a high level. By high level, I mean that the academic program of study that every high school graduate completes should be one of opening doors to all possibilities.

How can this high level of access to mathematics and science be achieved for every student? By providing a highly qualified teacher in every classroom and not just paper credentials, a content rich, conceptually based curriculum and learning resources.

In order to have highly qualified teachers, content rich, conceptually sound curriculum and learning resources consistent with the nature of the disciplines, it is essential that practicing mathematicians, scientists and engineers are involved in the process.

As to the question of how we can grow, educate, attract and retain the best and brightest scientists and engineering students, in order to have students achieve at proficient and advanced levels, they must be engaged in learning at proficient and advanced levels. Today we may be harvesting what we are planting. The following needs to be relentlessly supported:

1) One, returning teaching to its place as a respected profession. Research reports of the Education Trust and others show that the single most important factor in student achievement in mathematics and science is the concept depth of the teacher. Each individual teacher should be supported in developing a database of professional growth experiences to complement and advance his or her talents. As research is foundational to science and mathematics, teachers should be afforded the opportunity to participate in scientific and mathematical research that they can then translate into new learning experiences for their students.
2) Providing sufficiency of time for the generation of evidence of what works or does not, in what context, for whom and why it works. Involving scientists, mathematicians and engineers in the K–12 continuum is a relatively recent scenario. Therefore, we need the Federal Government to financially support the pilot endeavors at a sufficient level and for a sufficient amount of time.

3) Targeting and sustaining federal dollars. It is critical that federal dollars, whether transmitted through the National Science Foundation or the U.S. Department of Education, are targeted to the school districts involved rather than tangential. Tangential efforts have been shown to have limited, short-lived impact. Only school districts that have committed to transforming mathematics and science education and who have defined strategic efforts to engage university mathematicians, scientists and engineers should be provided the resources to accelerate the implementation of the already defined plan.

Relative to how K–12 higher-education partnerships can reduce the need for remediation, promote interest in math and science education and reduce the number of dropouts, especially for under-represented populations, we may need a paradigm shift with the following two items:

1) Assessment, accountability and motivation. We must be concerned with assessing the results we want, rather than those that are most easily measured but provide little meaning. Assessing the memorization of facts in science and basic computation in mathematics are not sufficient in preparing the scientific, mathematical or teaching workforce of the future. As the content of mathematics and science is enormous and ever expanding, we can no longer look to mere measurements of factoids, rather we must assess the conceptual understandings which are the underpinnings of science and mathematics.
2) Acceleration versus remediation. Rather than focusing on remediation, Georgia Tech has chosen to focus on acceleration. It is trite to say, but success breeds success. By engaging students in successful, yet challenging scientific experiences, learners come to recognize their innate potential.

Ultimately it is vital that all students be supported in access to, preparation for and participation in courses that will allow them to make individual decisions as to their post secondary options. Whether these decisions are made while in high school or a decade later, students should not be limited in their options for work, military, technical college or university pursuits by the judgment of others as to what course work they are capable of or may need.

The Nation and Georgia have experienced an increasing reliance on the scientific and technical skills of those beyond these shores. We must rededicate ourselves to the support of the human capital resident in our youth, the leaders of tomorrow and the economic engine of our future.

Thank you.

[Applause.]

[The prepared statement of Dr. Ohme follows:]

PREPARED STATEMENT OF PAUL OHME

Honorable Representative Gingrey, Members of the Science Committee of the U.S. House of Representatives and other citizens present, thank you for the opportunity to appear before you to address how elementary, secondary, and post-secondary mathematics and science education is critical to innovative scientific research and to our high tech economy.

There are four major points that I would like to make and expand upon in my remarks:

First, the single, most important step that the Federal Government should take to improve K–12 mathematics and science education is

- To create and support an unequivocal expectation that all children CAN and WILL learn mathematics and science at a high level.

Second,

- The single most important factor related to student achievement is a highly qualified, engaging, motivated teacher that is committed to the success of every student regardless of their background.

Third,

- Institutions of higher education, particularly mathematicians, scientists, and engineers are a key component in developing a seamless horizontal and vertical system of science, technology, engineering, and mathematics (STEM) education leading to a competent technological workforce.

Fourth, and this may be the most harsh to consider

- In order to have students achieve at proficient and advanced levels, they must be engaged in learning at proficient and advanced levels. Perhaps it should be considered that the reason, that more than one-third of the students tested on the National Assessment of Educational Progress (NAEP) perform at the below basic level, is because they are being taught at the below basic level. Perhaps the diminution of achievement overtime seen on the TIMSS assessment by students in the United States is because the teaching and curriculum are redundant rather than taking all students continuously to the next level. We may be harvesting exactly what we have planted.

Allow me to expand on these points. The mathematics, science and technological skills of the resident workforce present a quality of life issue for all communities. The ability to attract and sustain consequential employment opportunities is increasingly reliant on the conceptual understandings, reasoning adeptness, and technical skills found within science, mathematics and technology. In order for communities to thrive, it is imperative that students in these communities are supported in acquiring the depth of content knowledge and skills of mathematics, science, and technology sufficient for them to make personal choices and decisions that impact their communities. This *quality of life* embraces workforce competency, economic development, informed and engaged citizenry, and stewardship and delight in everyday phenomena encountered in the natural world.

Therefore, it is my premise that the single, most important step that the Federal Government should take to improve K–12 mathematics and science education is

- To create and support an unequivocal expectation that all children CAN and WILL learn mathematics and science at a high level.

By a "high level," I mean that the academic program of study that every high school graduate completes should be one of opening doors to all possibilities, rather than limiting the aspirations of any student based on the perceptions of others.

How can this high level of access to mathematics and science be achieved for every student? By providing:

- **A highly qualified teacher in every classroom.** That means a teacher with deep content knowledge, the ability to develop disciplinary understanding within each student, the confidence to assist every student in developing the skills and enthusiasm as a life-long learner, and the commitment that every child is capable and will learn meaningful mathematics and science.
- **A content rich, conceptually based curriculum** that supports every learner in developing disciplinary conceptual understanding that they can apply to familiar and unfamiliar, yet to be encountered, situations. This means that the curriculum is experientially based and allows students to apply their learning, the true evidence that learning has occurred. Therefore, the curriculum allows students to make connections to real world applications, including career knowledge in the context of the learning experience.
- **Learning resources** necessary for exploring the disciplines of mathematics and science consistent with the nature of these disciplines. This includes access to technologies, laboratory equipment, chemicals, and apparatus sufficient to explore natural phenomena as well as experiment to determine the

impact and consequences of changing variables in various situations. Students should be developing skills in developing empirical evidence, analyzing and synthesizing data, and evaluating the efficacy of the information they are examining to make informed decisions. These are skills that have life-long implications for success in all fields and for participating as informed citizens in this democracy and the global world.

Engagement of Mathematicians, Scientists, and Engineers

In order to have highly-qualified teachers, content-rich-conceptually-sound curriculum, and learning resources consistent with the nature of the disciplines, it is essential that *practicing mathematicians, scientists, and engineers* are involved in the process. These disciplinary professionals must be engaged in identifying and nurturing the future K–12 teachers of mathematics and science who will be the first teachers of the future scientists and mathematicians. These disciplinary professionals can contribute to ensure accuracy of scientific and mathematical content in the curriculum as well as fidelity to the nature of these disciplines, including scientific, analytical, thinking. It is critical that we come to consider the mathematics, science, engineering "pipeline" as including the classroom teachers themselves, as well as the mathematicians and scientists who teach them, as well as every student who is a potential scientist, mathematician, or engineer.

More than a mathematics and science pipeline, it is critical that we recognize mathematics and science education as part of a system, a cycle that must include attracting outstanding individuals to become teachers of mathematics and science, so that they can support, motivate, and advance the learning of the K–12 students they encounter, the future scientists and mathematicians. This means that current scientists and mathematicians must identify and support potential teachers of mathematics and science, just as they nurture the future scientists, mathematicians, and engineers. In other words, while we are working to attract the "best and the brightest" to become full participants in the technological workforce of the future, we must work as diligently to attract the "best and the brightest" to be teachers of mathematics and science. These teachers, disciplinary faculty, and K–12 learners are all part of the equation that has the potential to lead to workforce competency critical to innovative scientific research and to our high tech economy.

As to the question of how we can "grow, educate, attract and retain the best and brightest scientists and engineering students?" (Based on the involvement you have had with math and science education programs at the U.S. Department of Education and the National Science Foundation as well as those in the state of Georgia, what are the most important and effective components of these programs?)

I reiterate

- In order to have students achieve at proficient and advanced levels, they must be engaged in learning at proficient and advanced levels.

What are some of the factors that will contribute to every student learning at proficient and advanced levels? Beyond providing a highly qualified teacher, content-rich-conceptually-based curriculum, scientific learning resources, and substantively involving mathematicians, scientists, and engineers, the following need to be relentlessly supported:

- Returning teaching to its place as a respected profession to be considered by the best and the brightest as a noble and rewarding career choice.
- Providing sufficiency of time for the generation of evidence of what works (or doesn't), in what context, for whom, and why it works.
- Targeting and sustaining federal dollars.

The Professionalization of Teaching

Research reports of the Education Trust and others shows that the single most important factor in student achievement in mathematics and science is the concept depth of the teacher. Classroom teachers of science and mathematics must have facility with not only the study of science and mathematics but also the practices of science and mathematics. Professional growth experiences for teachers cannot be limited to random workshops and disconnected courses. Rather, teachers should be supported in an extensive professional growth continuum beyond initial certification. Each individual teacher should be supported in developing a database of professional growth experiences to complement and advance their talents. As research is foundational to science and mathematics, teachers should be afforded the opportunity to participate in scientific and mathematical research that they can then translate into new learning experiences for their students. It must be recognized that it is no more appropriate for every teacher to have the same set of learning experiences, than it is to presume that every high school student needs the same set of learning experiences. However, there should be agreement on the expectation of outcomes, knowledge, and skill to be demonstrated by every teacher, just as there should be a common set of high expectations of demonstrated learning and application for each child.

The challenge of enticing some of the best and brightest into the field of mathematics and science *teaching* cannot be overlooked as part of solution to problem of advancing the workforce competency related to innovative scientific research and to our high tech economy. The disparity in the salary that an engineer with a Bachelor's degree can command versus a teacher with a Bachelor's degree has contributed to making teaching a less attractive career. The problem of inviting outstanding individuals into the teaching of mathematics and science is compounded by the permeation of the societal challenges of poverty and violence into the school house. Therefore, we must be steadfast in establishing mechanisms to reaffirm teaching as a noble profession and in supporting teachers in their professional growth, with appropriate classroom resources and technologies, which promote them in taking their students to the highest level.

Sufficiency of Time and Evidence

Involving scientists, mathematicians, and engineers in the K–12 continuum is a relatively recent scenario. Therefore, we need the Federal Government to financially support the pilot endeavors at a sufficient level and for a sufficient amount of time to generate evidence of what works, where, and under what circumstances. Sustained federal funding is necessary in order to gain evidence on best practices when linking active mathematicians, scientists, and engineers to the education of K–12 mathematics and science teachers and their students. The recent support of the Federal Government for the *National Science Foundation's (NSF) Math and Science Partnership* is an exemplar of engaging practitioners, of education and mathematics, science and engineering, to address the acceleration and advancement of mathematics and science education for all.

Hallmarks of the NSF Math and Science Partnership are partnership, evidence and shared accountability resulting in institutional change among all core partners. This is unique among federal support and essential to success. It includes the substantive partnership of university/college mathematicians, scientists, and engineers with K–12 school districts, focused on generating evidence of effective practices in advancing the demonstrable achievement of all students in mathematics and science. Attached below is a copyrighted article taken from the Proceedings of the 2004 American Society for Engineering Education Annual Conference & Exposition describing some of Georgia Tech's experiences with university/K–12 partnerships.

The Comprehensive MSP, the Targeted MSP, and the Research, Evaluation, and Technical Assistance MSP awards have been supported for less than three years. The new MSP Teacher Institutes for the 21st Century are less than four months old. These programs are exceptional in that they are defining successful partnerships as being responsive to the distinctive characteristics of the local community, calling for joint planning among university and K–12 partners, clearly defining the role of each partner, benchmarking to demonstrate progress, creating mechanisms for self-correction, and requiring shared responsibility, benefit, and accountability.

It is essential that congress support the continuation of these efforts, in diverse communities, with different partners, and with varied foci in order to generate a sufficient evidential research base that can inform full implementation in school districts across the United States. As this evidence is generated in these experimentally NSF supported higher education and K–12 partnerships, the information can be used to invigorate broader implementation in school districts across the United States.

Targeting and Sustaining Federal Dollars

It is critical that federal dollars, whether transmitted through the National Science Foundation or the U.S. Department of Education are targeted to the school districts involved, rather than tangential. Tangential efforts have been shown to have limited-short-lived impact. Targeted federal dollars should be consistent with the local master plan for advancing mathematics and science achievement. Only school districts that have committed to transforming mathematics and science education and who have defined strategic efforts to engage university mathematicians, scientists, and engineers should be provided the resources to accelerate the implementation of the already defined plan.

Overtime, students and teachers in classrooms change. Therefore, true educational transformation cannot occur classroom by classroom. Whole mathematics and science system reform, which is seamless vertically and horizontally, must be implemented. Only school reform in which the university/college community are simultaneously changing to support sustained change over time, including the recruitment, training, and retention of outstanding individuals as teachers of mathematics and science, as well as the scientists, mathematicians, and engineers of tomorrow, will result in the quantum leap that is required to advance the technological economy of the U.S. in the 21st century. Only through the sustaining of targeted federal dollars over a period of five to ten years will we be able to garner the evidence to demonstrate the efficacy of such accountable-action-oriented partnerships.

Universal Implementation

The U.S. Department of Education is poised to play a pivotal role in supporting school districts in partnership with higher education in translating the lessons learned, the evidential-base garnered through MSP research efforts of NSF, into common practice in all classrooms across the country. While the flow of dollars for support of the U.S. Department of Education Math and Science Partnership are just starting to be distributed, it is important that local partnership, involvement of mathematicians and scientists, and accountability be maintained as individual States make decisions as to which best practices they will promote.

Related to how K–12-higher education partnerships can reduce the need for remediation, promote interest in mathematics and science education, and reduce the number of dropouts, especially for under-represented populations, we may need a paradigm shift within the following:

- Assessment, Accountability, and Motivation
- Acceleration versus Remediation

Assessment, Accountability, and Motivation

As we are concerned with elementary, secondary and post-secondary math and science education in its criticality to innovative scientific research and to our high tech economy, we must be concerned with assessing the results we want, rather than those that are most easily measured, but provide little meaning. Assessing the memorization of facts in science and basic computation in mathematics are not sufficient to preparing the scientific, mathematical or teaching workforce of the future. The mathematics and science content knowledge of today is much vaster than when we were in school and continues to escalate at an incredible rate. If you look at just a few of the top ten list of scientific discovers in 2002, as reported by *Science Magazine,* you will discover heretofore unheard of roles for various RNAs, including micro-RNA-s, elementary-particle physics involving solar neutrinos (a mystery for the past thirty years), and progress in the field of genome studies that will make it possible to defeat malaria and hunger. Nanotechnology, chaos theory, and fractals were unknown just a few decades ago. As the content of mathematics and science is enormous and ever expanding, we can no longer look to mere measures of factoids. Rather we must assess the conceptual understandings, which are the underpinnings of science and mathematics. We must assess the critical ways of thinking, analyzing, synthesizing, evaluating and generating new knowledge that are the signature of the scientific and mathematical disciplines. We must find ways of assessing the applications of these concepts in new situations. Only by developing assessments that allow teachers and professors to determine what students appear to understand, as well as to diagnose misconceptions so that they can be addressed, will we successfully develop the next generation of scientific leaders, teachers, and citizens.

The Federal Government must support the development of appropriate measures for assessing the advancement of achieve in mathematics and science. In holding partnerships, schools, communities and universities accountable for improving scientific and mathematical learning, attention must be paid to motivational processes rather than solely punitive disincentives.

Acceleration versus Remediation

Rather than focusing on remediation, Georgia Tech has chosen to focus on acceleration. That is to say, that the pre-college and college support programs are designed to immerse all involved, whether pre-college students, their teachers, or undergraduate and graduate students in the exciting content that is science, mathematics and engineering. By engaging learners at every level in meaningful content and continuously successful experiences in learning, we are increasingly attracting more and more people to the opportunities resident in careers in scientific academia, industry, and teaching. It is trite to say, but success breeds success. By engaging students in successful, yet challenging, scientific experiences, learners come to recognize their innate potential.

CEISMC Endeavors

Most engineering-scientific Research-1 institutions, particularly those without a College of Education, focus on generation of new knowledge and the training of the next generation of scientists, mathematicians, and engineers. However, since the early 1990's, the Georgia Institute of Technology (Georgia Tech) has supported CEISMC (the Center for Education Integrating Science, Mathematics, and Computing) in improving the beginning of the intellectual pipeline, the K–12 students, in mathematics and science. Through CEISMC, Georgia Tech, links together the intellectual and research expertise of scientists, mathematicians, and engineers, their graduate students, and undergraduates with the K–12 teaching practitioners and their students. Through CEISMC's Teaching and Learning Camps, teachers' scientific and mathematical content and pedagogical skills are advanced with applied curriculum developed in concert with researchers. Middle grades students participate in these summer camps thus extending their curriculum beyond their regular school classroom and inspiring them to return to school with renewed enthusiasm for their ability to learn science and mathematics.

Professional Development

Another professional development opportunity sponsored by CEISMC is the Georgia Industrial Fellowships for Teachers (GIFT) program. This is a partnership with the scientific, mathematical, and technological corporate sector, university researchers, and schools, which places veteran teachers in scientific and corporate research experiences for six to eight weeks each summer. Since GIFT's inception more than 750 placements have been made, with an average of 75 placements each year. These teachers are supported by mentors to translate their research experiences into classroom learning activities for their students once they return to their classrooms. In both settings, teachers take ownership of their professional growth and positively comment on how they have been re-energized in their teaching of mathematics and science and feel renewed as a professional.

Linking Practitioners and Learners

Georgia Tech's Student and Teacher Enhancement Partnership (STEP), an NSF sponsored GK–12 program partners Georgia Tech graduate and undergraduate students with teams of teachers at six majority-minority metro-Atlanta high schools per year with three primary goals: To use the unique talents and energy of the Georgia Tech students to help address the pressing needs at the schools; to promote long-term, mutually beneficial, and multi-faceted partnerships at these school; and to provide the Georgia Tech students with a teaching internship experience that would benefit their professional growth and subsequent career, whether in academia, industry, or education. In its third year, fifty-six graduate applicants applied for thirteen slots, with 54 percent filled by African American students.

Evaluation of this program shows that all participants, teachers, their students, graduate students and undergraduates (paired with graduate students) have benefited from this program. Among the outcomes for graduate students are academic content mastery, academic efficiency, professional skills, presentations and publications, interest in teaching and advanced pedagogical skill. Schools benefit from student instruction in cutting-edge science and mathematics, instructional materials development, student mentoring, access to educational technologies, support for student research, professional development for teachers, and connections to the Georgia Tech campus. Providing access and linkages to undergraduates, graduates, and faculty researchers gives students, many of whom will be first generation college students an understanding of the power and possibility, which exists within them if they apply themselves. These students can visualize themselves in these successful experiences for the first time, because they are given access and support.

In addition, this work is generating a new body of knowledge related to Partnerships which bridge the cultures of K–12 and universities in which scientists, mathematicians, and engineers are substantively engaged. Three stages of partnership encompassing six factors of embeddedness, strategic needs, formation, operation, process outcomes, and performance outcomes are described. (See *Partnering Across Cultures: Bridging the Divide between Universities and Minority High Schools,* M. Usselman, D. Llewellyn, D O'Neil, and G. Kingsley).

Pre-college Mentoring

But success can only occur when each student is fully supported with outstanding teachers, a meaningful conceptually based curriculum, and scientific learning materials, as well as a community of individuals letting each student know they can be successful. The latter can be accomplished through a number of mentoring approaches. CEISMC partners with corporate mentors, such as BELLSOUTH employees, in working with teachers and middle grades students early enough in their education to support them in embracing success in science and mathematics. CEISMC's Mentoring Program (CMP) links undergraduates as mentors with middle and high school students.

Pre-College Advanced Curriculum

While providing mentoring experiences for students engaged in Advanced Placement Calculus and Computer Sciences, CEISMC is also partnering with three metro-Atlanta school districts in the expansion of their advanced learning programs. While each of the CEISMC collaborative efforts has linked university disciplinary faculty and loaned CEISMC specialists to the school districts to develop programs to increase participation and success, particularly among minority students, to honors and advanced coursework, each of these endeavors is unique to the school districts (Cobb, DeKalb, and Atlanta Public Schools), and therefore reinforces a core premise of all CEISMC's work, that is it must be responsive to the needs of the school districts. A cookie-cutter approach does not work, in mentoring, professional development, or in curricular programs.

Pre-College Technology

In keeping with the notion of acceleration rather than remediation, CEISMC is developing websites that focus on engaging students and their families in the power, fascination, and career opportunities resident in science, mathematics, and engineering. CEISMC also develops websites for collaboration among teachers, mentors, participants, and faculty in order to increase the opportunity for continued interaction and "just-in-time-learning." The latter refers to when a learner is working along and encounters something that is particularly challenging, they can share that challenge and work collaboratively to surmount and own the necessary understanding.

Continuous Support—Once at Georgia Tech

While the primary focus of CEISMC–Georgia Tech's efforts are at the pre-college level, while impacting the collegiate level, Georgia Tech has a number of successful programs which have proven to support accomplishment, particularly among minority students. OMED (Office of Minority Education) serves Georgia Tech under-represented students—African American, Hispanic, and Native American—through a strategy of academic success and persistence through "prevention." OMED's research has found a strong correlation between the minority students first term GPA and their graduation rate five years later. Consequently, Georgia Tech's goal is to work toward a minority graduation rate of 85 percent with a cumulative GPA of 3.0 as the standard for academic performance. OMED fosters this through its "academic pre-season" embodied in programmatic pieces for entering students. Georgia Tech supports students in academic transition programs that provide continuous analysis and assessment with real-time feedback as students are supported in their academic immersion experiences. OMED's activities have shown an increased closing of the gap among Black students retention benchmarked against the total Georgia Tech population, and shows that Hispanics are retained at a higher rate than either Blacks or the Georgia Tech population. More detailed information relating to OMED is attached.

FOCUS

Georgia Tech is also focused on the success of under-represented populations at the graduate level. FOCUS is a graduate student recruitment program rooted in marketing: marketing Tech, marketing Atlanta, and marketing graduate school. The experience opens these students, many of whom are first-generation college graduates, of the potential research and educational opportunities waiting for them. Many under-represented college graduates are focused first on entering the world of employment, without having the opportunity to consider the benefits of graduate study. FOCUS is a collaboration of Georgia Tech and the King Center. It invites minority graduates to a four day experience in Atlanta. It not only exposes students to the faculty and facilities of this Research-1 Institute, but also to the history of the city as the seat of the civil rights movement. It is no small wonder that FOCUS is timed to coincide with the city's celebration honoring Martin Luther King, Jr.

These efforts are demonstrating success. Tech currently holds the distinction of being first in the number of Master's degrees and doctoral degrees conferred upon African-Americans. It is notable that one-third of the graduate-level students enrolled at Georgia Tech participate in FOCUS.

Summation

Ultimately, it is vital that all students be supported in access to, preparation for, and participation in courses that will allow them to make individual decisions as to their post-secondary pursuits. Whether those decisions are made while in high school, or a decade later, students should not be limited in their options for work, military, technical college, or university pursuits by the judgment of others as to what course work they are capable of, or may need. The single most important factor related to student achievement is a highly qualified, engaging, motivated teacher that is committed to the success of every student regardless of their background. But additional supports, through meaningful curriculum, learning resources, mentoring, and bridging/transitioning support programs have demonstrable impacts on student success. This is true for students under-represented in the fields of mathematics, science and engineering as well as those well represented. Finally, the nature of partnership among universities and K–12 schools is critical and must embrace mutual respect, shared benefits, and responsiveness to the needs of all involved.

The Nation and Georgia have experienced an increasing reliance on the scientific and technical skills of those beyond these shores. We must rededicate ourselves to the support of the human capital resident in our youth, the leaders of tomorrow, the economic engine of our future.

WHAT DOES

OMED: Educational Services

DO?

OMED: Educational Services has served Georgia Tech's underrepresented students (African-American, Hispanic, and Native American) since 1979. Our philosophies and strategies have made us successful in our retention of these students and in the implementation of performance initiatives for this target population.

Since 1990, OMED's main strategy has been to emphasize academic success and persistence through "prevention."

This strategy resulted from OMED's recognition of the strong correlation between minority students' first term GPAs and their graduation rates five years later. This information has compelled OMED to work toward a minority graduation rate of 85% (also GT's goal) with a cumulative GPA of 3.0 as the standard for academic performance.

OMED hopes to foster these goals through the "academic pre-season" concept embodied in the programmatic pieces offered to entering students.

OMED Philosophies and Strategies:

1) Foster an atmosphere of academic excellence by:
   a) immersing students in an academic environment while setting high academic expectations
   b) continually analyzing and assessing model-based programs (i.e. Challenge, Team Coach, and GT Transitions)
   c) providing real-time feedback for mid-course corrections with student coaching and mentoring
2) Provide freshmen and upper class transition programs that:
   a) focus on information strategies for transition to GT (academic preseason)
   b) bring context to initiatives by using GT graduates as program managers

   c) teach student strategies that help students to understand:
      - that they are responsible for their GT destinies
      - the effects grades have on their GPA (e.g. how a five hour "A" helps and how a five hour "F" hurts)
      - the bell curve grading structure
      - how to choose a sensible course load early on
      - how to partner with parents
      - the power of proper rest, and time management
      - how to seek creditable academic advice
      - how to use structured self assessment/planning strategies (e.g., whether or not to use AP credits)
      - how to use all available resources (e.g., labs, student coaches/peers/groups with superior students)

3) OMED garners our reputation for providing the best academic help by:

a) selecting the best tutorial assistance available
b) partnering with academic departments and faculty for program staffing and operation
c) soliciting continuous feedback from our clients, the Georgia Tech students

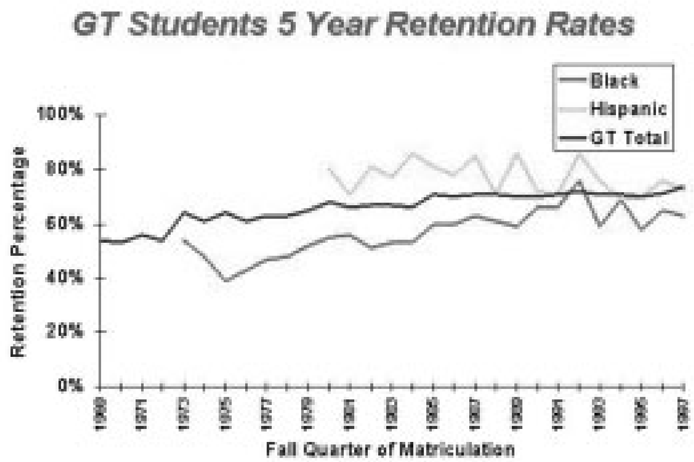
4) OMED reaffirms academic success by:

a) rewarding superior academic performance (i.e., Tower Awards)

b) establishing a culture of excellence (using ceremonies, paraphernalia, print media, etc.)

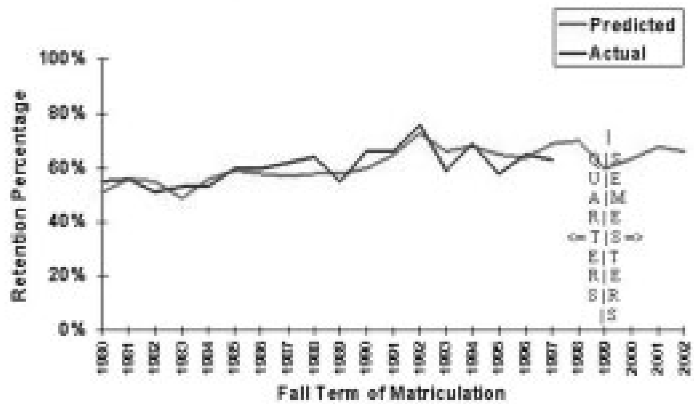
Lastly, it is our sincere belief that our OMED strategies work for all students; not just those in our target population.

Minority Historic Retention and Graduation Rates



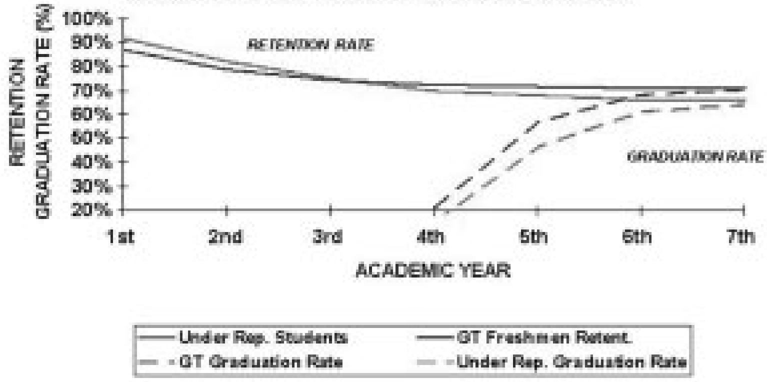
Retention is one benchmark by which academia measures itself. This figure represents the five year retention rates for blacks, Hispanics, and the overall GT population. As illustrated, the black retention rate continues to close the gap to the Tech benchmark. Likewise, Hispanics have been better retained than both blacks and the overall GT population. The inconsistent views of both the black and Hispanic population are due to the small sample sizes.

Black Students 5 Year Retention Rates

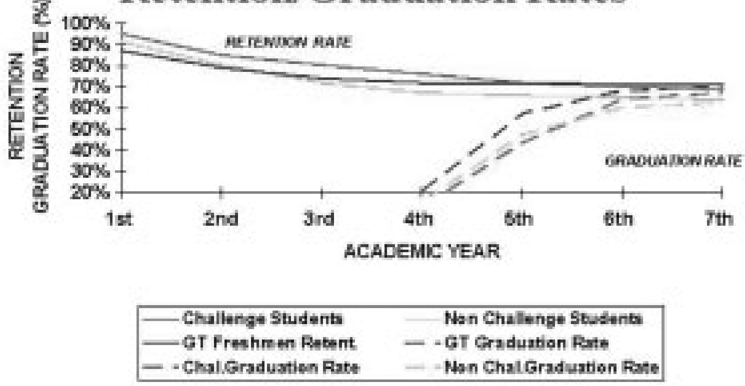


Based on retention models that have been developed in our office, we are able to predict how well black students are retained. This chart shows a steady improvement toward our minority retention goals.

Underrepresented Students
Academic Years (1990 – 2002)
Retention/Graduation Rates



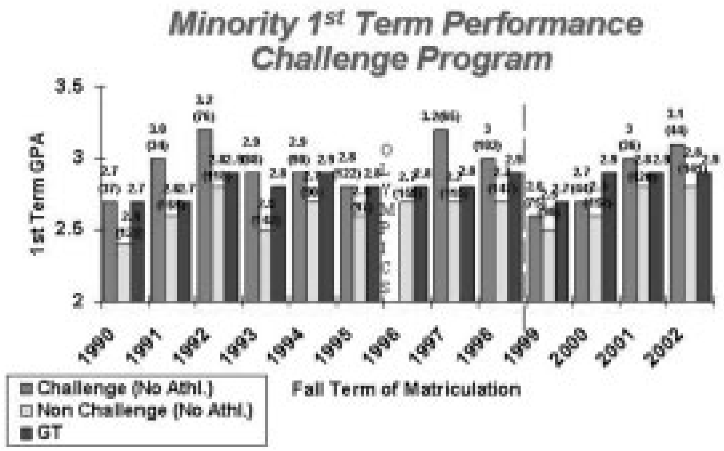
Underrepresented Students
Academic Years (1990 - 2002)
Retention/Graduation Rates



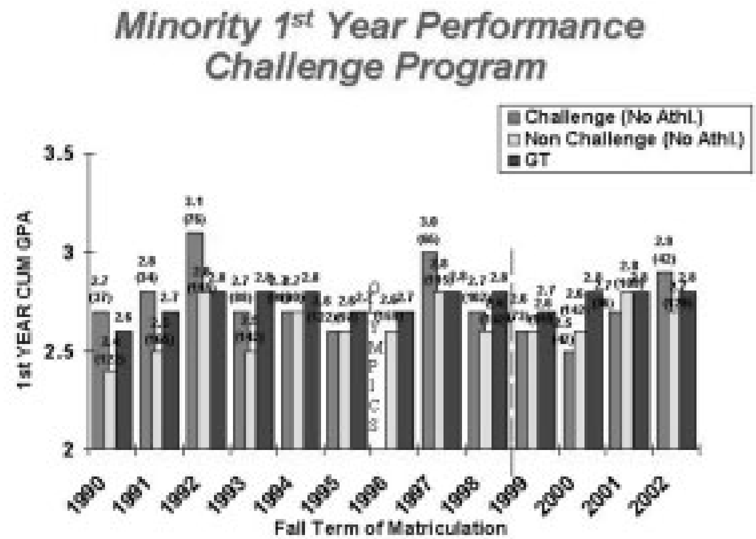
These two charts show the retention and graduation rates of the minority population as compared to that of the general population. In tracking Challenge program participants for five years, we have found that the retention and graduation rates for that program's participants are very comparable to those of the general population.

In other words, students who participate in our programs are very competitive with the general population.

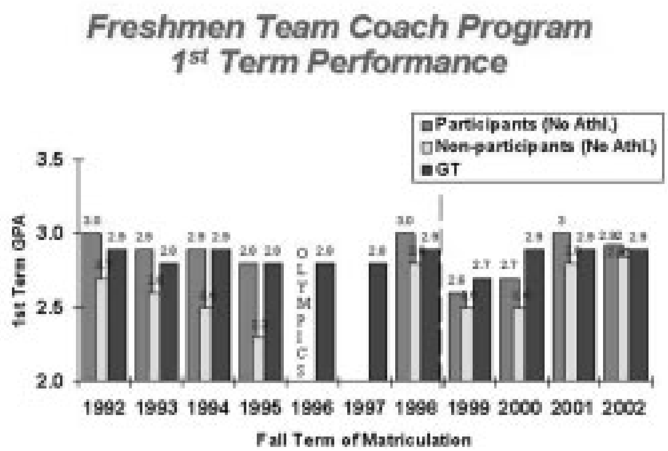
Minority Academic Performance 1st Term & 1st Year (Challenge)



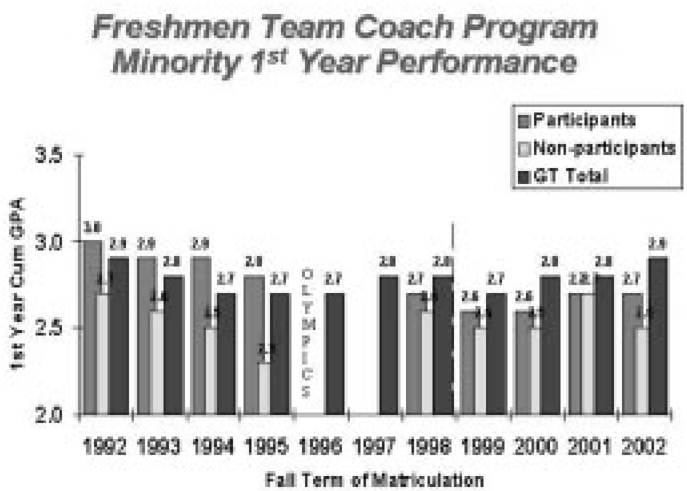
This chart compares the first term performance of the minority population to that of the majority. It reveals that participants in the Challenge program generally outperform the majority population in their first term.



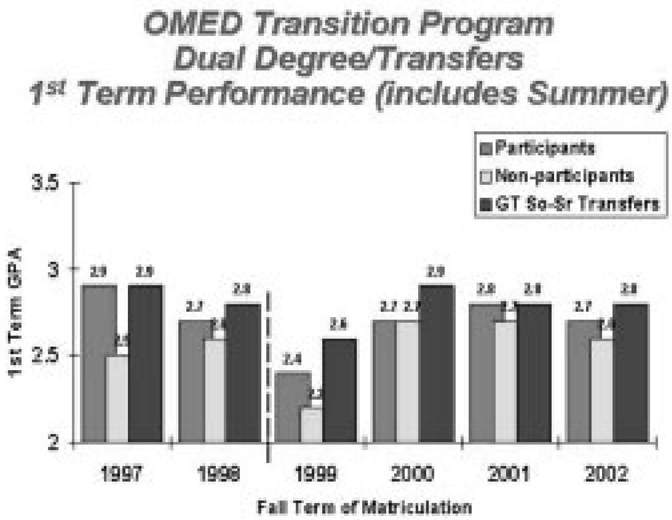
Freshmen Team Coach Program



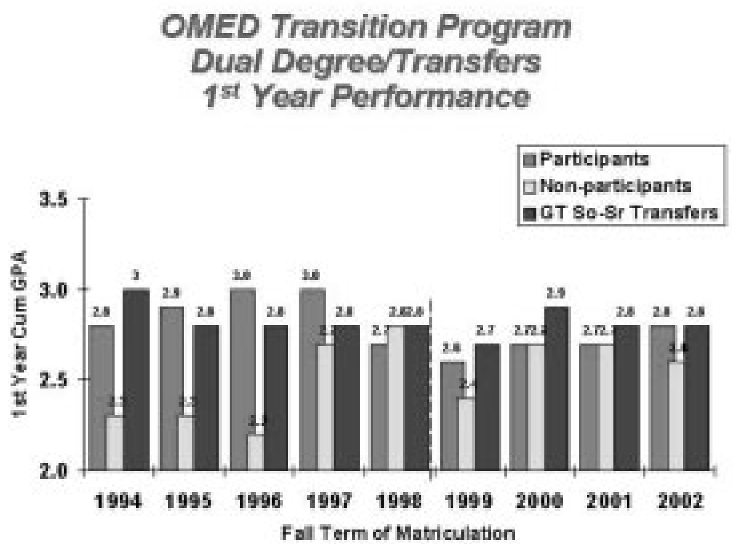
As was the case with the Challenge program participants, Freshmen Team Coach program participants often outperformed the general student population in their first term.



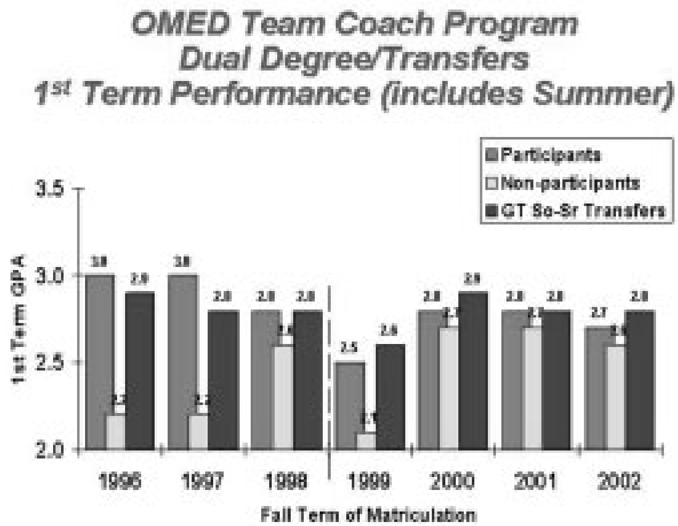
Dual Degree/Transfer Transition Program

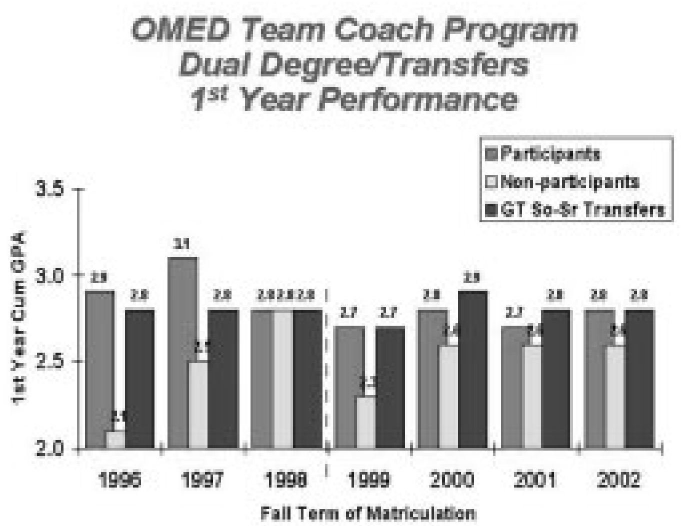


Dual Degree/Transfer Transition program participants are highly competitive with the GT general population. The data clearly demonstrate the effectiveness of such programs.



Dual Degree/Transfer Team Coach Program


OMED Team Coach Program
Dual Degree/Transfers
1st Term Performance (includes Summer)
Participants
Non-participants
GT So-Sr Transfers
1st Term GPA
3.5
3.0
2.5
2.0
1996
1997
1998
1999
2000
2001
2002
Fall Term of Matriculation


OMED Team Coach Program
Dual Degree/Transfers
1st Year Performance
Participants
Non-participants
GT So-Sr Transfers
1st Year Cum GPA
3.5
3.0
2.5
2.0
1996
1997
1998
1999
2000
2001
2002
Fall Term of Matriculation

The Dual Degree/Transfer Team Coach program's effectiveness is confirmed by its participants' high level of competitiveness with the GT majority population. In many instances the participants outperform their counterparts.

Again, it is evident that the support provided by this program during student transition is a strong contributor toward the minority population's academic success at Georgia Tech.

Simultaneous increases in student retention and academic performance are significant—usually one improves at the expense of the other (e.g., after a "population" change). Here, the "culture" changed. The post-1990's minority performance, when viewed from the historic (1980-1989) minority perspective, serves to reinforce the worth of the academic pre-season concept.

Georgia Tech's Hispanic students' superior retention and academic performance is a credit to their hard work and focus. These students have leveraged their common language and culture to succeed. A critical contributor to their success is their willingness to share learning strategies amongst one another—a staple OMED philosophy. The goal is that in time, all minority retention and academic performance will meet—if not exceed—that of the Georgia Tech general student body.

Attachment

Partnering Across Cultures: Bridging the Divide between Universities and Minority High Schools

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GEORGIA INSTITUTE OF TECHNOLOGY

Abstract

The historical mission of most engineering-dominated Research-1 universities is to create new knowledge and to train students in technological fields. In the absence of a College of Education, and given an institutional culture prioritizing scholarly research, institutions such as Georgia Tech often do not have a long history of systemic faculty involvement in the K–12 educational community. However the current national focus, initiated by public funding agencies such as the National Science Foundation, encourages academic scientists and engineers to shoulder some of the responsibilities for the quality of science, technology, engineering and mathematics (STEM) education at the K–12 level, and to do this by developing university-K–12 "partnerships." Unfortunately, given the vast cultural differences that exist between universities and K–12 schools, these partnerships too often flounder, never managing to bridge the divide to the point of mutual trust, mutual respect, and mutual benefit.

We are currently in the third year of an NSF-funded GK–12 project, the Student and Teacher Enhancement Partnership (STEP)[1], and are preparing to embark on a five-year extension. A major part of this project has been the building, nurturing, and grooming of partnerships between Georgia Tech and local minority high schools. As part of this project we have developed a model of partnerships that is grounded in the public policy literature and that describes the evolution of the partnerships created between Georgia Tech and four minority-dominated high schools as part of STEP. In this paper we will describe the theoretical framework of the partnership model, outline ways to assess partnership outcomes, and apply this model to the STEP program case study.

Theoretical Framework of a Partnership Model

As part of a separate NSF-sponsored research project, we are examining how partnerships influence STEM educational outcomes in NSF's Systemic Initiatives Program and Math and Science Partnerships Program.[2] We do so by exploring how the emergence, operation, and in some cases, dissolution of partnerships influence the process by which STEM educational outcomes are pursued and achieved. For the purposes of this research, we define *partnerships* as voluntary arrangements between organizations, anchored by agreements, to promote the exchange, sharing, or co-development of products or programs designed to stimulate STEM education.[3] Partnerships are a particular form of inter-organizational collaboration. However, they are distinctive in that participants are not merely bound by mutual interests. They have also developed agreed goals and responsibilities for achieving these

[1] NSF Award Number 0086420.

[2] NSF Award Number 0231904. We are in our second year of this three-year project. For more details on this research, "Alternative Approaches to Evaluating STEM Education Partnerships: A Review of Evaluation Methods and Application of an Inter-organizational Model," please visit the project website at http://www.prism.gatech.edu/~gk18/STEM

[3] This definition draws from Gulati and Gargiulo's (1999) definition of alliances among firms. Their work provides a general summary of how alliances emerge and develop products, technologies and services.

goals.[4] Such agreements are usually articulated in formal contracts, memoranda of understanding, or statements of work. However, we do not exclude the informal "hand-shake" variety of agreement in our definition. We also note that the term *organization* is applied loosely to include the organized interests of parents and other interest groups.

In the multidisciplinary field of public policy research, partnerships have been studied from multiple perspectives including organizational theory and inter-organizational relations. Inter-organizational studies are the umbrella from which studies of organizational networks, partnerships and alliances have emerged.[5] In other policy contexts inter-organizational conceptual foundations have been used to study the relationships among firms, not-for-profits, public agencies, and in public-private partnerships. Researchers from myriad disciplines have contributed to the conceptual foundations of inter-organizational studies including scholars from business, sociology, economics, public administration, and anthropology. These studies have been pursued using a wide-variety of research methods including cluster analysis, graph and network analysis, qualitative case studies and social mapping techniques, and various statistical regression techniques. Consequently, inter-organizational concepts cover a wide range of partnering behavior and provide an analytic language that is sufficiently developed and useful to span the multidisciplinary world of STEM education.

While many STEM education programs may seek to link partnership efforts to positive outcome variables such as increased student achievement, researchers and evaluators from several fields have noted that studies of interoganizational relations (such as partnerships) rarely address outcomes.[6, 7, 8] It is far more common for partnership studies to try and explain the reasons for the formation and structure of relationship rather than subsequent actions and value-added to the individual partners.[9] Alternatively, studies will posit that partnership is a positive factor and then provide evidence to support the premise.

Another issue is that partnerships are often treated as rational, strategic acts which organizations form to control or influence their working environment. From this perspective organizations enter into the partnership as a means of gaining information, control over their strategic environment, or to secure vital resource flows.[10] However, this is an under-socialized, overly rational point of view that does not account for existing relationships in which an organization is embedded.[11] Partnerships also emerge because organizations have a long-standing working relationship and one is persuaded by another to participate. Organizational institutionalists argue that rationales for participation in a partnership may be strategic, but they may also be coercive, mimetic, or persuasive as well.

There is also a difficulty in inter-organizational studies in articulating when a failure has occurred. Studies have found a high incidence of failure amongst partnerships and joint ventures.[12] However, there has been a good deal of uncertainty regarding when a partnership has failed. For example, studies have concluded that failure is represented by the end of the partnership. If the individual parties to the partnership have achieved their goals and agreed to dissolution then it does not seem appropriate to label such an experience a failure. Even if only a few of the participants to a partnership benefit while others do not, then the result can be ambiguous. In the case of STEM educational outcomes the ultimate determination of success for many political and educational leaders is improvement in the perform-

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[4] Boyers, E.L. (1981). "School/college partnerships that work," *Current Issues in Higher Education,* Vol. 1, p. 4–10.

[5] Galaskiewicz, J. (1985). "Inter-organizational relations," *American Review of Sociology,* Vol. 11, pp. 281–304.

[6] Gulati, R. and M. Gargiulo (1999). "Where do inter-organizational networks come from?," *American Journal of Sociology,* Vol. 104, no. 5, p. 1439–1493.

[7] Kingsley, G. and J. Melkers (2000). The Art of Partnering across Sectors: The Importance of Set Formation to Network Impacts in State R&D Projects. In L. O'Toole, Hal Rainey, and Jeffrey Brudney (Eds.), *Advancing Public Management: New Developments in Theory, Methods, and Practice.* Washington, DC: Georgetown University Press.

[8] Provan, K.G. and H.B. Milward (2001). "Do networks really work? A framework for evaluating public-sector organizational networks," *Public Administration Review,* Vol. 61, no. 4, pp. 414–423.

[9] Oliver, C. (1990). "Determinants of inter-organizational relationships: Integration and future directions," *Academy of Management Review,* Vol. 15, pp. 241–265.

[10] Burt, R.S. (1992). *Structural Holes: The Social Structure of Competition,* Cambridge, MA: Harvard University Press.

[11] Gulati, R. (1998). "Alliances and networks," *Strategic Management Journal,* Vol. 19, pp. 293–317.

[12] Kanter, R.M. (1989). *When Giants Learn to Dance,* New York: Touchstone, Simon, and Schuster.

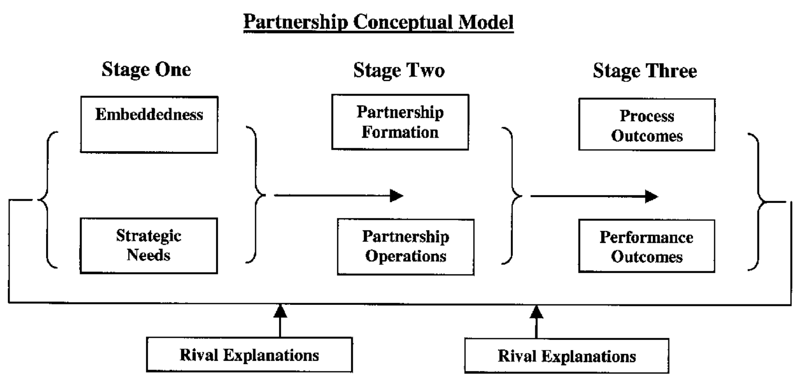
ance of students in their abilities and on test scores. Even partnerships that have dissolved may have served their purpose in creating a climate to engender and sustain these improvements.

A final issue in evaluating partnerships is the transportability of successful partnerships from one setting to another. A form of partnership that is found to be effective in a rural setting may not apply well in an urban area. Affluence, community culture, or ethnic diversity may act as additional contingencies affecting the link between partnership and educational outcomes. Essex (2001) offers seven characteristics of effective partnerships between a K–12 school and a university but cautions against of one-size-fits-all application.[13] Sirotnik and Goodlad (1988) also warn against becoming too focused on a single model of effective collaboration.[14]

To develop a useful tool for evaluating STEM partnerships, models must be robust enough to address these challenges. This means that the model should attempt to establish clear relationships between the partnership and the desired outcomes. There must also be a clear focal relationship (e.g., a particular dyadic partnership, or a network of organizations, or an individual organization). Success and failure need to be judged in terms of the overall objectives of partnership rather than measuring failure through the participation of individual members. And studies must build towards robustness by being comparative not only between highly embedded and non-embedded organizations, but also among partnerships in different types of communities (e.g., advantaged vs. disadvantaged; homogenous vs. heterogeneous; large vs. small school system; or rural vs. urban geographic location).

Partnership Conceptual Model

Through this research, we are developing a conceptual model for linking partnerships and outcomes. Six concepts are drawn from organizational and inter-organizational relations studies into a conceptual model that links the pre-conditions for partnership, with partnering activities, and finally partnership outcomes.



Stage One

This model captures the pre-existing conditions in terms of strategic needs and the embeddedness in relations among organizations prior to the partnership.

- *Embeddedness* describes the number and types of relationships that organizations have with one another prior to the development of a partnership.
- *Strategic needs* describes the types of resource and legitimacy needs confronting individual organizations prior to a partnership and whether there is a congruence or complimentarity in these needs.

The concepts of embeddedness and strategic needs are not mutually exclusive and are likely to work in concert. In Table 1, we offer a two by two matrix describing some of the possible combinations. Each partnership or set of partnerships within a STEM project can be classified according to this chart.

[13] Essex, N.L. (2001). "Effective school-college partnerships: A key to educational renewal and instructional improvement," *Education,* Vol. 121, no. 4, p. 732–737.

[14] Sirotnik, K. and J. Goodlad (1988). *School University Partnerships in Action,* New York: Teachers College Press.

Table 1: Positive Embeddedness and Congruent Strategic Needs

Level of embeddedness	Congruence of Strategic Needs of Partners: Low	High
Low	I	II
High	III	IV

Embeddedness may occur in either a positive or negative form. Two organizations may know each other well, have lots of experience working together, yet really dislike and distrust the other. Thus, each partnership will have to be classified as high (negative) or high (positive) in terms of embeddedness. In Table 1, low levels of embeddedness may signify that the two organizations have little history of working together. Similarly, all organizations have strategic needs. The issue in this model is whether those needs are 1) strategically related to the objectives of the partnership, and 2) congruent or complementary.

Just because partnerships fall outside of quadrant IV does not predict that they will be a failure in terms of process and performance outcomes. But it does indicate that the nature of partnership needs to be adapted to reflect these conditions. For example, partnerships in quadrant II exhibit high levels of congruence among partners in their ability to satisfy strategic needs through the project. But these organizations are low on embedding meaning that they do not have a history of working together. We would anticipate that the partnership process variables of stage two will exhibit higher transaction costs and formalization of agreements if this partnership is to be successful. Similarly, partnerships in quadrant III have high levels of embeddedness but low congruence of strategic interests. In order to achieve successful outcomes the partnership must devise ways of building on the pre-existing trust among organizations with incentives that motivate the partners to fulfill their duties to the partnership. Finally in quadrant I partners do not have embedded relationships nor is there much in the way of congruent interests. Such partnerships are likely to be marriages of convenience bound by the desire to secure grant monies or other resources.

Stage Two

The third and fourth concepts describe the types of partnering activities that develop. These concepts are designed to describe the process of partnering and include the following:

- *Partnership formation* describes the types of agreements regarding the goals, resource allocations, and responsibilities of each party to the partnership. This concept captures the collective intent of the partnership and includes the following ideas:
    - *Partnership Goal*—Partnerships take aim by setting objectives that engage the full complexity of the problem or may focus on a narrower slice of the issue. The wider the focus the more likely the partnership is to require the intervention, reinforcement, and support of resources outside the school system. For example, it is not uncommon in math-science education (or in other subjects as well) for students to have a view of their life and development that does not include the application of these basic educational tools. Challenging this perception requires not only the personal interventions of the schools but also may require challenging a community culture that lacks of vision of the possibilities associated with these tools. Effectively addressing a student's need for math-science edu-

cation may require enlisting role models and resources beyond those the school can provide.

- *Partnership Agreement*—Refers to the number and types of formal agreements that are entered into among the partners as a means of achieving process and performance outcomes. In general, researchers have found that embedded relationships require less formalization over time.[15] Thus, we might predict that partnerships with positive patterns of embeddedness would require fewer agreements in order to reach positive outcomes. Attempts to formalize such arrangements may actually work to hinder such good results.
- *Partnership Focus*—Organizations are not monoliths. Instead they are comprised of groups of professions, coalitions, and operating divisions. Partnerships vary in terms of the types of different groups that have some form of interaction with one another. For example, organizations may be highly embedded but not in the relationships that are critical for the objectives of the project. For example, school system administrators may have excellent working relationships with universities. But their teachers may have no experience in interacting with university representatives. This means that for the purposes of improving teacher performance the high levels of pre-existing embedding may not produce the normal types of benefits associated with these relationships. One way of capturing this is to identify the number and types of different groups engaged in each partnership.
- *Partnership Complexity*—Refers to the number of different organizations and activities within the partnership. Complexity has been posited to have four dimensions: vertical, horizontal, sectoral and spatial. Vertical refers to whether the partnership is organized into a hierarchy with clear lead organizations and clear followers. Horizontal complexity refers to the number of peer organizations operating at the same level and on similar tasks. Sector-based complexity refers to the number of organizations drawn from the public, private, and not-for-profit sectors participating in the partnership. Spatial complexity is the number of different geographic locations involved in the partnership. Highly complex partnerships are more difficult to operate and keep focused on partnership objectives, but there are also more opportunities for spillover benefits due to additional extra-partnership collaboration.

- *Partnership operations* describe the actual behaviors in which the partners engaged as they pursue the goals and duties of the partnership. This concept includes the following:
  - *Partnership Interdependence*—Refers to the extent that partners depend upon each other for resources or materials to accomplish the partnership objectives. Three types of interdependence have been identified: pooled, sequential and reciprocal. Pooled refers to relationships that are not highly interdependent where each partner works fairly independently. Sequential refers to relationships where the work of one partner feeds into the work of another partner and this second partner is not able to proceed until the work of the first partner is accomplished. Under reciprocal interdependence each partner must share work back and forth until it is completed. Reciprocal relationships are the most interdependent form of partnership.
  - *Transaction Costs*—These are the costs that organizations absorb in the implementation of a task. In partnerships transaction costs are almost always high because the participating organizations have to adapt to each other's method of doing business. Transaction costs can be higher if individuals from different professions are interacting (usually requiring that each learn a bit of each other's language) or if different sectors are involved (as individuals from the private and public sectors adapt to the particular rules that govern their home organizations).
  - *Partnership Communication*—This refers to the frequency with which partners interact and the direction of these interactions. One of the more common complaints in university-school partnerships is that the communication flows are largely one-way with universities providing informa-

[15] Galaskiewicz, J. (1985). "Inter-organizational relations," *American Review of Sociology,* Vol. 11, pp. 281–304.

tion and resources to schools. These patterns may be highly embedded and even be high in congruent interests if they contribute to the professional development of school systems and/or teachers. However, when confronted with a challenge as difficult as reforming STEM education outcomes, greater dialogue may be required in order to achieve positive outcomes.

Stage Three

The final two concepts describe the types of outcomes that develop from the partnership. These concepts are designed to capture the results of the partnership.

- *Process outcomes* describe the qualitative and quantitative assessments that measure whether the partnership actually achieved the goals and duties of operation. For example, under *process outcomes* we may observe whether partners were able to implement a common curriculum across schools, marshal resources among partners, bring together the support and talents of universities, parents, businesses and not-for-profits, or achieve congruence among policies.
- *Performance outcomes* assess such improvements as in the working environments of teachers, enhancements in their ability to engage in STEM education, and assessments of the performance of students on STEM topics.

Stage One and Two variables in the partnership model describe how pre-existing conditions and strategies of partnering need to be matched in order to produce positive outcomes. This is particularly true with *process outcomes.* Under Stage Two partnership variables we observe the types of interactions, agreements, resources, foci, transaction costs, etc. that are associated with a project. Stage Three outcome variables capture the degree to which these efforts are translated into conditions for successful STEM partnerships.

The Student and Teacher Enhancement Partnership (STEP) Program—Case Study

The Student and Teacher Enhancement Partnership (STEP) program, funded for three years by the National Science Foundation as part of the GK–12 program, with a continuation for another five years (as STEP Up![16]), partners Georgia Tech graduate and undergraduate students with teams of teachers at six metro-Atlanta high schools per year. The discussion that follows applies the conceptual model of partnerships to the STEP program, analyzing the program based on the theoretical concepts described. A total of ten high schools, widely distributed geographically throughout the Atlanta metropolitan area and in terms of socio-economic status, have participated in the STEP program over the past two and one-half years. We will limit the current discussion to the partnership with four primarily African American schools in Fulton and DeKalb Counties.

In this report we examine the body of data collected during the STEP evaluations and organize this information using our partnership model. In doing so, we attempt to observe both the variance in partnering-related activities and the evolution of the partnership over time.

Partnership Assessment Strategy for STEP

The findings for this study are drawn from the on-going evaluation of the STEP program. Because the STEP program is in the early stages of development the assessment strategy is currently formative in nature, emphasizing qualitative data collection methods and descriptive analysis of the partnerships. The key evaluation issue is whether the STEP program enhances math and science partnerships (in this case between Georgia Tech, the school districts and the high schools) by introducing Fellows as a resource for teachers. Thus, in addition to the variables described above, several key relationships served as the focus for the larger evaluation:

1) Evidence of enhanced math and science partnerships between Georgia Tech, the school districts, and the high schools.
2) Evidence of effective working relationships between high school teachers and the STEP Fellows.
3) Evidence of benefits to teachers, Fellows, and high school students from participating in the STEP program.
4) Identification of factors that facilitate or hinder the achievement of the impacts identified in previous three points.

[16] NSF Award Number 0338261.

The principle evaluation method employed during the first few years is to develop case studies of each of the high schools participating in the STEP program. The narrative in each case describes the implementation of STEP from the perspective of each of the partners. In addition to the case studies, the data is examined according to the roles that individuals play within STEP. Thus, aggregate narratives are developed for Fellows, Teachers, Coordinators, and Advisers. A variety of data sources are used in this study including:

- Semi-structured interviews with Fellows, teachers, advisers, coordinators, and STEP administrators.
- Surveys of Fellows following the summer training programs for STEP.
- Document reviews of the action plans for each high school.
- Document reviews of lesson plans and assessment tools developed by the STEP Fellows.
- In-class observations of the STEP Fellows.
- Review of journals maintained by the STEP Fellows of their experiences within the high schools.

Input from high school students was also compiled through presentations and information from the STEP Fellows, such as videotapes and student evaluations conducted by individual teachers or STEP Fellows.

Stage One: Embeddedness

The STEP program has provided a way to partner Georgia Tech with four primarily African American high schools in which it historically has had few ties. It is worth mentioning that many of the local African American-majority schools view the local majority-white universities with a large amount of distrust, a point of view rooted in segregation and in the fact that minority schools in the southern United States have traditionally been forced to operate with far fewer resources than their white counterparts. In addition, universities often initiate “reforms” in local schools that are short-lived, leading to a healthy skepticism by veteran teachers about the university’s long-term commitment. University academic faculty often approach projects presuming that they know better than the school personnel how to solve the problems of K–12 education, causing teachers to be suspicious that university involvement will just create additional work for them. The distrust is also fueled by the legacy of segregated southern universities (including Georgia Tech), by the current debate about affirmative action and the fairness of standardized exams such as the SAT, and by the lack of cross-cultural dialog between African American and Caucasian students who have never sat next to, nor competed academically with, students from the other race. So in many ways, the pre-existing relationships between the individual majority-black schools and the majority white universities are fraught with historical baggage, are examples of communities with vastly differing cultures and expectations, and therefore exhibit very low levels of embeddedness. However the central administration of these large, urban, school systems are often experienced at partnering with local universities, which provides an effective initial point of entry.

Stage One: Strategic Needs

For the High Schools

The four schools participating in this partnership all post low standardized test scores, and on most measures of academic achievement (including the percent of students requiring academic remediation in college) they perform well below their majority-white suburban peer schools. The demographics and 2001–2002 academic performances of the partner schools are listed in the table below.

High School	School System	# students	% Under-rep. Minorities	% Reduced lunch	Ave. SAT	% passing AP test
Cedar Grove	DeKalb	1585	100%	47%	884	7%
Stone Mountain	DeKalb	1400	92%	54%	888	6%
Tri-Cities	Fulton	1893	94%	42%	868	22%
Westlake	Fulton	1266	99%	33%	898	22%

The need for increased academic achievement is therefore easily demonstrable. However precisely which strategic needs are addressed by the STEP partnership? They are the needs endemic in low performing schools where the teachers are under great stress to improve academic performance at the same time as they are coping with student disengagement, transient student populations, and lack of parent involvement or support. In other words, they are:

- The need for extra adults to assist with developing and implementing laboratory exercises.
- The need for assistance with locating and coordinating educational excursions, and for planning after school clubs and organizations.
- The need for assistance in taking advantage of educational and funding opportunities.
- The need for role models and mentors for students.
- The need for expert content resource people to aid both teachers and students.
- The need for support for the use of educational technology.

On the other side, what are the strategic needs of Georgia Tech that are satisfied by STEP, and are these needs congruent and/or complementary to the needs of the schools system? Georgia Tech's needs are:

- The need for opportunities for graduate students to gain leadership, communication, and teaching skills.
- The need for graduate students and faculty members to have approved avenues for engaging with and giving back to the community. This is particularly true for our African American graduate students.
- The need for faculty to engage in educational outreach and workforce development activities to help them attract external research grants.

The needs of the two partners are therefore largely congruent since the university partners satisfy their needs through interacting with the school system partners.

Stage Two: Partnership Formation

Partnership Goals

- To use the unique talents and energy of the Georgia Tech students to help address the pressing needs at the schools;
- To promote long-term, mutually beneficial, and multi-faceted partnerships at these schools; and
- To provide the Georgia Tech students with a teaching internship experience that will benefit their professional growth and subsequent career, whether in academia, industry, or education.

Partnership Agreements

The Science Coordinator or Deputy Superintendent for Curriculum from each participating school system selected schools to participate in the STEP Program. The schools selected were ones that had demonstrated need, but that also had well-functioning leadership and the capacity to partner. Because of the disproportionately high participation rate by Georgia Tech African American graduate students and the high level of need in the predominantly black Atlanta-area schools, we decided after Year 2 to concentrate most of our efforts on the issues of the primarily black schools.

Partnership Focus

Two Graduate Fellows and a teacher coordinator form the initial central core of the STEP team at each school. As the partnership progresses at a school and the capacity of the school to effectively expand the partnership increases, undergraduate students are added to the mix, or new ventures, such as a pilot using a social science graduate student, are added. This increased school capacity usually takes the form of an increase in the number of teachers who claim ownership of the school-Georgia Tech partnership and who understand the value of, and the optimal ways of interacting with, the graduate Fellows. In each school the partnership has evolved differently. The STEP staff provides guidance and consultation, but the central philosophy of STEP is that the nature of the partnership is defined by the people directly involved. The STEP co-PIs choose the graduate Fellows, give them training, and put them into the field to work in ways that best fit their talents and inclinations and that most effectively address school needs.

Partnership Complexity

Vertical Complexity—Georgia Tech is the lead STEP organization, maintaining partnerships with multiple high schools. However substantial effort has been invested in moving the relationship away from a leader and follower status, and encouraging the high schools and teachers to take the lead on initiating projects. However the central STEP administration effectively holds the project together.

Horizontal Complexity—STEP involves multiple high schools, and multiple Georgia Tech academic units, centers, and laboratories. In this regard, the project is highly complex, and relies on creating multiple horizontal connections between independent entities. However since only one university is involved, this decreases the problems of multiple collaborations between peer institutions.

Sectoral Complexity—STEP is primarily a partnership between the university and the schools. However long-term sustainability probably requires that additional partners be added from the private sector. STEP has initiated a campaign to attract private sponsors, which will undoubtedly add to the complexity of the general partnership.

Geographic Complexity—STEP operates only in metro-Atlanta, within commuting distance for the graduate Fellows. This simplifies many aspects of the partnership.

Stage Two: Partnership Operation

Partnership Interdependence

The STEP PI and co-PI do not dictate what the team is to do, but instead serve to “run interference” and ensure that the program runs smoothly, that the activities are consistent with the goals of the program, and that all of the team members are communicating effectively. The partnerships with each school are reciprocal, requiring that each side initiate actions, and follow through with support for the other side.

Transaction Costs

The most substantial cost of STEP is in the graduate Fellow stipends, tuition, and other associated cost-of-education expenses. Money is also invested in the form of staff salaries. Therefore in this partnership, components with “high transaction costs” are usually defined as those that take lots of time and energy from the STEP staff and from the graduate Fellows.

At the school level, each STEP team is led by a Teacher Coordinator who is paid a $2,500 stipend. That teacher is responsible for recruiting colleagues into the program, and for overseeing the placement and activities of the STEP Fellows. Each Teacher Coordinator is provided with $2,000 for materials and supplies, and $1,000 to support teacher professional development activities. Additional teachers who become involved with the program are provided with financial compensation, up to a total of $2,000 per school. In addition, each STEP Fellow is provided with money for supplies—$500 per graduate student, and $250 per undergraduate student.

Partnership Communication

Many of the most serious problems that have arisen during STEP can be traced to a breakdown in communication that leads to different expectations between participants, such as between a Fellow and a teacher. We have learned that prompt and regular communication, regular monitoring of graduate Fellow activities, and a willingness to quickly change course when people are dissatisfied serves to minimize the problems that stem from poor communication. One problem of partnering with minority schools is that the school personnel often are not comfortable using e-mail, which is the primary mode of communication at the university. This state appears to be changing, however, making the communication routes much easier.

Stage Three: Process Outcomes

As indicated in the Partnership Assessment Strategy section above, STEP outcomes at this stage are primarily: 1) evidence of enhanced partnerships, 2) evidence of effective working relationships, and 3) evidence of benefits to teachers, Fellows, and high school students. These outcomes are described under Performance Outcomes. Process Outcomes include the actual operation of the partnership, and the infrastructure developed to support the program. These are detailed below.

STEP Summer Training Course

Before they are placed in the classroom, STEP Fellows receive ten weeks of training during the summer at the start of their fellowship period. The goals of this training are three-fold: to start the work of building partnership teams and planning for the academic year; to give the Fellows a "toolbox" of knowledge and resources to use once they arrived at the high schools; and to provide ample opportunity to explore relevant topics in education and to practice using the tools that they are learning. The expectation is that at the end of the ten weeks the Fellows will be ready to be fully participating members of the teams at the schools, ready to act as content expert resources and to engage with the teachers as partners in the educational mission of the high school classroom.

School-Based Partnering Activities

The action plan, developed by each school team, details the types of activities that best fit the needs of the school and the talents and professional and personal desires of the Fellows. Examples of the activities include:

- *Student Instruction*—Fellows can assist partner teachers with instruction in the classroom in the form of hands-on laboratory experiments, group research projects, active group discussions of science topics, and/or short lectures on content.
- *Instructional Materials Development*—Fellows can develop instructional materials, or adapt existing materials to reflect more inquiry learning. The learning objectives covered depend completely upon the needs of the specific classroom.
- *Student Enrichment and Mentoring*—Fellows are often involved in direct tutoring and mentoring of students, and in coordinating activities such as high school chapters of the National Society of Black Engineers (NSBE Jr.) and Science Olympiad.
- *Educational Technologies*—Fellows can provide teachers and students with assistance in implementing educational technologies in classroom projects and curricula, including initiating web-based classroom resource and discussion pages.
- *Student Research and Science Fair Projects*—Fellows provide invaluable assistance to students in conceptualizing a viable science experiment, providing feedback on the appropriate uses of the scientific method, assisting with locating appropriate research equipment and supplies, reviewing experimental progress and data, and advising on presentation of results.
- *Teacher Professional Development*—Fellows have designed and implemented staff development activities for teachers, often focusing on the use of educational technology.
- *Georgia Tech Connections*—Fellows are very effective at increasing the linkages between Georgia Tech and the partner schools. Graduate students are plugged into the events in their departments and in the broader university community, and are constantly reviewing these connections with an eye towards applicability to the high school community.

Graduate Fellow Participation

Recruitment: Despite initial skepticism by Georgia Tech faculty and administrators, the STEP program has become increasingly and highly popular among graduate students, particularly among the African American graduate students (see chart below). We attribute this to the strong involvement by black graduate students in community involvement and civic leadership activities, and to a powerful "word of mouth" promotion of the program within the minority community at the institute. The table below shows the ethnic and gender breakdown of the applicants and participants in the program for the first three years. Note the progressive increase in application number. (B=black, W=white, O=other, M=male, F=female.)

STEP Applicants	BM	BF	WM	WF	OM	OF	??	Total
Year One	4	4	7	6	1	0	3	25
Year Two	10	4	9	2	4	4	11	44
Year Three	15	7	16	8	2	1	7	56
STEP Participants								
Year One	3	3	3	3	0	0	0	12
Year Two	4	4	4	0	0	0	0	12
Year Three	4	3	3	3	0	0	0	13

Between years one and three, the number of academic units represented by those applicants grew from five departments in two colleges to eleven departments in four colleges.

Stage Three: Performance Outcomes

STEP is, in essence, a grand experiment in partnership building. Can a highly technical, majority white, university, over an eight-year period, build meaningful partnerships with low-income and predominantly minority schools that will outlast the individual people and the external support, and that will yield quantifiable benefits to both sides?

Indications of Partnership Building

Sustainable partnerships must be built upon the efforts, concerns, and agendas of many people if they are to survive the departure of the original players. Bearing this in mind, our philosophy has been to encourage all STEP participants to expand the partnership network whenever possible, and to include academic departments, individual laboratories, campus offices, student organizations, business and industry partners, and professional societies on the university end, and as many teachers, school clubs, administrators, and students as possible on the K–12 end. Thus far, the most noteworthy aspects of this partnership infrastructure include:

- *Involvement by Large Numbers of Academic Units at Georgia Tech, including:*
    - 9 academic units in the College of Engineering
    - 4 academic units in the College of Sciences
    - The College of Computing
    - 2 academic units in the Ivan Allen College (for Liberal Arts and Social Science).
- *Active Participation by Minority Organizations.* Georgia Tech graduates more black engineers than any other institution in the country, and the Georgia Tech Black Graduate Student Association, and the National Society of Black Engineers (NSBE) have been two of our strongest partners. The black graduate students have also involved the FOCUS program (which encourages minority participation in graduate school), the FACES program (Facilitating Academic Careers in Engineering and Science), EMERGE (Empowering Minority Engineers to Reach for Graduate Education), as well as 100 Black Men of Atlanta.
- *Involvement by NSF-funded Engineering and Science Research Centers.*
- *Direct School-University Lab Partnerships* to foster research opportunities for teachers and high school students.
- *Involvement by Georgia Tech Offices and Organizations,* notably the Office of Undergraduate Admissions, the Women's Resource Center, and the Division of Professional Practice.
- *Involvement by Increasing Numbers of Teachers at Partner Schools.*
- *Involvement by High School Students in Georgia Tech-Sponsored Enrichment Activities.*

Graduate Student Outcomes

All Fellows, at the end of their tenure, answer the journal question "What did you gain from being a STEP Fellow?" In answer, the graduate students wrote:

"An extreme sense of satisfaction at the contribution I made to my students' lives—no matter how small it was. It was also the first experience I've had that

has made me seriously consider teaching as a career. I've even recommended it to several people." Black female, 4th year chemistry Ph.D. student

"The biggest thing that I gained was confidence. I have no problem standing in front of a class and lecturing." White female, 2nd year mechanical engineering Master's student

"The STEP program has changed my career objectives. I now want to, ultimately, use my Ph.D. to develop educational programs for high schools. I want to create partnerships between industry and high schools. Don't ask me how just yet; my thoughts are still evolving." Black male, 5th year physics Ph.D. student.

"I gained teaching and leadership experience. This experience has shown me how much I really enjoy teaching despite the shyness in my personality. The joy of seeing a student learn supersedes my insecurities. The burden I feel when I look at the problems that face our communities, compels me to share what I have learned from school, so that other can break cycles and achieve the best in life." Black male, 5th year Ph.D. electrical engineering student

Teachers also provided unsolicited comments about the partnership:

"I need to tell you how much [the Fellow's] presence has meant to me. This has been my first year back in teaching after 23 years in industry and I had little idea of the level of the problems I would encounter. [The Fellow] has served as a confidant, a sounding board, another set of eyes, and a friend during this year. Further he has added a creative element by way of his ideas and suggestions. His contribution has been significant, not only to the program here but also to my sanity. I have had a sense of isolation because of the limited adult interaction available here and even though [the Fellow's] days here were limited, they were a breath of adult communication. His insight and willingness to delve into what we were seeing was useful. We have evolved many understandings of the problems here. . .and after the summer break I will be refreshed to start again." Written by a participating physics teacher

"Hi. Last day of school here. Paperwork completed, reflecting for a moment. Wanted to commend to you on [the two Fellows'] work. They made this old teacher a believer. [One Fellow] brought a steadiness and steadfastness with her. Dedicated to labs, and slugging it out. [The other Fellow] brought fire and brimstone. He gave us 100-plus summer enrichment programs of which our kids are attending. . ., brought us to Calvin Mackie's talk, Lego Mindstorm, aided in interviewing Governor's Honors nominee, and big-brothered one of our students helping him gain admittance to NC A&T. I would term this year a success. See you soon!" Written by a participating chemistry teacher

Evaluation of the STEP program's effect on graduate students, using the assessment methodology described earlier, has revealed positive outcomes in:

- *Academic Content Mastery:* Graduate students teaching high school students must convey knowledge so that it is comprehensible to students who come from varying achievement levels and backgrounds. This requires that knowledge be thoroughly understood, condensed and distilled to improve its efficacy, a skill that has incomparable value for graduate students.
- *Teaching Interests:* Hands-on teaching experiences provide graduate Fellows with early opportunities to elucidate their interests in teaching as a profession—whether at a high school or college level. These teaching experiences require novel approaches to conveying knowledge to students, thereby encouraging creativity in a Fellow's own research objectives.
- *Academic Efficiency:* A graduate student's skill at time management strengthens through time spent with students—both inside and outside of the classroom. Most graduate Fellows willingly spend more time contributing to the program than is required. To accommodate this, graduate students conduct their research and schoolwork in a more efficient manner.
- *Professional Skills:* Working in a high school classroom helps Fellows improve their leadership, communication, and pedagogical skills and better-define their future professional and academic goals and objectives. It also provides them with models of rewarding community service that are applicable to their future career, whether in education or industry.
- *Presentation and Publications:* During the first two years of the project STEP Fellows have participated in seven professional presentations, co-authored three conference papers, and attended three NSF workshops and seven professional meetings in their role as STEP Fellows.

Teacher and School Outcomes

The teachers and school administrators have all been highly enthusiastic about their participation with the STEP program. Many have stated that STEP is unlike any other school enhancement program they have ever seen, and that among all of their school "partners," Georgia Tech is their best one and is the only one that actually provides meaningful classroom help. The benefits to the school, teacher, and students most often mentioned to the evaluation team have been:

- The injection of fresh energy into the classroom by the Fellows.
- The value to teachers of understanding the cutting-edge research that takes place at the university, and the value to high school students of being exposed to what the science and mathematics are used for at a higher level.
- The ability of the Fellows to provide novel and different ways of thinking about, and presenting, science and mathematics content, and to introduce the students to educational enrichment opportunities outside of their school.
- The access that the teachers and students gain to science materials, supplies, and equipment.
- The effectiveness with which the Fellows are able to transform the high school students' thinking about science from a view that science is a bunch of facts, to an understanding that science is a process, and a way of thinking.
- The additional time the Fellows provide for teachers to do other necessary school-related duties. Fellows also help teachers keep their "sanity" under difficult conditions, hopefully increasing the likelihood that the good teachers will stay at these challenging schools.
- The Fellows, particularly the African American Fellows, serve as invaluable mentors for the predominantly minority high school students. They are role models, tutors and cheerleaders, and always fight against the tendency of schools to lower the bar for minority students.
- Teachers gain access to summer research experiences at Georgia Tech, through the *Georgia Industrial Fellowships for Teachers* (GIFT) program, and can build personal connections with faculty and lab personnel. After Year 1, one STEP teacher participated in GIFT. During the summer after Year 2, 13 teachers from STEP schools participated in research internships at Georgia Tech as part of the Georgia Tech (GIFT) program, supported primarily by Research Experiences for Teachers NSF grant supplements.

Though many of these benefits are difficult to quantify, they are very tangible to the individual teachers. For the four overwhelmingly African American schools in the program, STEP is *the* reform initiative within the science department. It provides the teachers with a sense of being special, and a hope that together the school and Georgia Tech can improve the situation they face and help them direct their students towards productive and gainful careers. In essence, the partnership provides the teachers and schools with an invaluable door to Georgia Tech, through which pass lab and classroom resources, science and engineering faculty speakers, high school students on laboratory tours, admissions officers bearing crucial advice, and undergraduate student volunteers. These are all types of resources that are traditionally unknown and unavailable at the African American schools but are commonplace at majority-Caucasian affluent schools (that each send dozens of students per year to Georgia Tech, and where many of the parents are connected to the university, either as an alumnus, a faculty member, or a member of the corporate elite). These "ripples" of resources extending from the partnership core are vital to the growth and vitality of the partnership; Fulton County's Tri-Cities High School STEP program, described below, gives a good example of this ripple effect in action. Tri-Cities and Georgia Tech had no existing relationship before STEP began in 2001.

Tri-Cities has now hosted seven graduate students and two undergraduates over a three-year period. The partnership ripples include: 1) High School students initiating a junior chapter of the National Society of Black Engineers (NSBE) (linked to the Georgia Tech NSBE chapter) which hosts academic activities and competitions, 2) Four science teachers participating in summer research internships in Georgia Tech Biology and Electrical Engineering laboratories, 3) Two teams of high school students conducting research projects at Georgia Tech, supported by the Siemens Foundation, 4) A College of Computing professor and Ph.D. graduate student piloting a new computer-based art program at the school, 5) A science teacher and faculty member from Aerospace Engineering collaborating on a grant to create a high school research-based Astronomy class, 6) Students from Tri-Cities American History classes exchanging visits with Georgia Tech students enrolled in a Social Policy course, 7) Tri-Cities students participating in internet conversations with students at Georgia Tech, and students in Russia and Sweden, 8) The minority recruitment team from Georgia visiting the school multiple times, 9) Teams of high school students participating in a Lego Mindstorm competition sponsored by Mechanical Engineering, 10) High school students visiting Georgia Tech to hear motivational speakers, 11) Students and teachers attending Biotechnology demonstrations, and 12) A relationship of trust and respect developing between people at Tri-Cities and Georgia Tech.

The Evolution of the STEP Partnerships

As we are in the third year of STEP in several of our partner schools, we are now in a position to evaluate the initial success of our partnership building, and to look towards sustainability. The following evolutionary model of the development of a university-high school partnership based on graduate Fellows is now becoming apparent. It is also apparent that these stages cannot be rushed since the trust necessary for building true partnerships takes time to develop, and is based on actions over time, not on abstract plans.

Year 1—Initial Steps

Goal—To develop an understanding by both university and school partners of the program's potential at that school.

- Graduate Fellows are introduced, and form personal bonds with school staff.
- School personnel develop an understanding of program possibilities, trust about university motives, and confidence of sustained university interest.
- The university partners analyze school's use of Fellows and the partnering capability of the school staff.
- The university partners assess whether the "need" is there-Does the partnership have the potential to have a major effect, or is it merely icing for a school which functions fairly well already?

Year 2—Maturation and Expansion of the partnership.

Goal—To establish the university as a "real" partner—i.e., one that can be trusted to continue for the long haul.

- The school transitions to a second graduate Fellow team. Teachers and school personnel learn that the partnership is not dependent on specific graduate students.
- The team of teachers and graduate students develop a broader concept about what the school's needs are, and how the university might interface with them.
- The network of teachers with "ownership" of the partnership expands.
- Multiple connections are developed between the high school and academic units and organizations at the university, including linking schools to particular research labs.
- Teachers are encouraged to come to the university as summer research interns.
- The team begins developing high school research teams to come to university labs.
- Undergraduate students or additional graduate students join the school teams where the partnership capacity allows it.

Year 3—Beginning Institutionalization.

Goal—To increase the number of "owners" of the partnership.

- Schools transition to a third graduate Fellow team and university-school connections expand.
- School system personnel become involved in the graduate Fellow summer training program.
- The partnership gains increased visibility and ownership among high-level administrators from both school system and university.
- Schools are encouraged to actively instigate additional school-university connections, thereby empowering teachers to ask for what they need.
- Staff seeks out and promotes partnerships and sponsors from the private sector.

All of the STEP partnerships are actively evolving and expanding. The goal of the next five years of STEP is to solidify the partnerships, creating enough linkages that the connections become sustainable without the infusion of NSF funds.

Conclusion

Though there is a current national emphasis on developing partnerships between universities and K–12 schools, there has been little discussion on exactly what is meant by a "university-school" partnership, and very few theoretical frameworks exist for describing the best way of achieving sustainable and effective partnerships in education. The Partnership Conceptual Model described in this paper and drawn from the partnership literature from the field of Public Policy emphasizes the importance of pre-existing conditions (in terms of embeddedness and strategic needs) and the structure of the partnership (in terms of formation and operations) when predicting the success of the project outcomes. STEP is a partnership that began with congruent strategic needs and a high degree of embeddedness with the school system administration, but a low degree of embeddedness where it really counts, namely at the individual school level. Therefore high initial transaction costs, in the form of large amounts of time and effort, were required to develop the connections with the schools, and the necessary personal trust, that ultimately have led to a deeply embedded partnership and a higher chance for long-term successful outcomes.

With STEP the emphasis has been placed on the development of a healthy partnership and the final outcomes are allowed to evolve from the partnership. In our experience, this is not the most common orientation of educational partnerships; many are driven by particular prescribed activities, or based on curricular units developed by higher education. As illustration, one of the NSF reviewers for the STEP Up! GK–12 continuation grant stated:

> *"The process of creating the partnerships and working with the teachers is not new, original nor particularly creative. What is novel is the creating of the partnerships first and then letting what happens happen. This takes courage and faith in the participants. It also takes very secure college level faculty who are willing to treat their high school teachers as peers. This is obviously happening here with very imaginative results."*

Our experience suggests that the partnership itself is particularly important when trying to connect and effect change in entities with very different cultures, such as majority-white universities and majority-black schools. Only when the partnership is strong, and the different partners have trust in one another, can change take place. And only when there are clear mutual benefits and trust can a partnership outlast the external funding stream and sustain over time.

Biographic Information

MARION C. USSELMAN

Dr. Marion C. Usselman is a Research Scientist at the Center for Education Integrating Science, Mathematics and Computing (CEISMC) at Georgia Tech. Marion received her Ph.D. in biophysics from Johns Hopkins University and focuses on equity issues in education and K–12 educational reform. Marion is a co-PI of the STEP NSF grant, and a co-PI on the Alternative Approaches to Evaluating STEM Education Partnerships NSF grant.

DONNA C. LLEWELLYN

Dr. Donna C. Llewellyn is the Director of the Center for the Enhancement of Teaching and Learning (CETL) and an Adjunct Associate Professor in Industrial and Systems Engineering at Georgia Institute of Technology. Her current areas of research are in equity of engineering education, and assessment of instruction. Donna is the PI of the STEP NSF grant.

DARA V. O'NEIL

Ms. Dara V. O'Neil is a Research Associate at the Georgia Tech Research Institute, and a doctoral candidate in Information and Telecommunications Policy in the Georgia Tech School of Public Policy. She is a co-PI on the Alternative Approaches to Evaluating STEM Education Partnerships NSF grant.

GORDON KINGSLEY

Dr. Gordon Kingsley is an Associate Professor in the School of Public Policy at Georgia Institute of Technology. Gordon is the project evaluator for the STEP NSF grant, and PI on the Alternative Approaches to Evaluating STEM Education Partnerships NSF grant. His area of research interests are the interactions of public-private partnerships to harness developments in science and technology, and the nature and assessment of educational partnerships.

BIOGRAPHY FOR PAUL OHME

Primary Program Responsibilities

CEISMC Director

Educational Background

Ph.D. Mathematics (Differential Equations). Florida State University.

MA Mathematics. University of Alabama.

BA Mathematics/Minor: Physics. Huntington College.

Administrative Experience:

Georgia Institute of Technology—Director, CEISMC—1996–Present

Northeast Louisiana University
- Associate Vice President for Academic Affairs—1993–1996
- Member, President's Cabinet—1993–1996
- Member, NLU Strategic Planning Committee—1994–1996
- Head, Department of Computer Science—1984–1993
- Coordinator of Computer Science—1980–1984

Mississippi College—Coordinator of Academic Computing—1973–1979

Teaching Experience:

Northeast Louisiana University
- Professor of Computer Science—1987–1993
- Associate Professor of Computer Science—1980–1987

Clemson University
- Visiting Associate Professor of Mathematics (NSF Grant)—1979–1980

Mississippi College—Associate professor of Mathematics—1973–1979

Franklin & Marshall College
- Assistant Professor of Mathematics (Consultant for integrating computers into the mathematics curriculum)—1971–1973

Florida State University—Graduate Assistant—1966–1971

Mississippi College—Instructor—1964–1966

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CEISMC

January 21, 2004

The Honorable Sherwood Boehlert
Chairman, Science Committee
2320 Rayburn Office Building
Washington, DC 20515

Dear Congressman Boehlert:

Thank you for the invitation to testify before the U.S. House of Representatives Committee on Science on January 23rd for the hearing entitled "Fueling the High Tech Workforce with Math and Science Education." In accordance with the Rules Governing Testimony, this letter serves as formal notice of the following Federal funding. For the past three yeas, I have not personally received any federal funds. However, the center for which I direct, CEISMC/Georgia Tech, has received funds for the National Science Foundation and the U.S. Department of Education as indicated below.

- $299,272.00, RE216-079/5231704, University of GA/Athens/Inter-Math: Internet, Enhanced Mathematics in Grades 4-8, July 1, 1999 - June 30, 2006
- $27,425.00, RH216-090/2278827, University of GA/Athens/Science Teacher Enhancement Program Based on NASA's Missions and Facilities, March 15, 2001 – May 10, 2002
- $21,999.00, RH216-106/4183217, University of GA/Athens/Globe Training for City Schools of Decatur, March 25, 2002 – June 30, 2003
- $49,111.92, AGMT DATED 1 FEB 2003, Pramm Consulting Group Inc/Reston, VA/Expert Consulting for P-20 Education, February 1, 2003 – September 30, 2003
- $21,471.00, RH216-090/2278837, University of GA/Athens/Underground Railroad Elementary Program, March 15, 2001 – May 10, 2002
- $100,693.00, SRV03CRL-041, University of North Carolina/Chapel Hill/Charting a Course for School Improvement, July 1, 2003 – December 14, 2003
- $45,154.00, RE216-079/5231704, University of GA/Athens/Inter-Math: Internet, Enhanced Mathematics in Grades 4-8, July 1, 1999 – June 30, 2003
- $210,000.00 (annually), Atlanta Public Schools/Atlanta Urban Systemic Initiative, September 1, 2000 – August 31, 2003

Sincerely,

Paul Ohme, Director

Mr. GINGREY. Thank you, Dr. Ohme.
We will now hear from Mr. Michael Cassidy.

STATEMENT OF C. MICHAEL CASSIDY, PRESIDENT, GEORGIA RESEARCH ALLIANCE

Mr. CASSIDY. Mr. Chairman, Congressman Davis, good morning. It is a distinct pleasure and honor for me to join this discussion today and to provide testimony to this committee on a subject that is of great importance to me professionally and personally, as I am sure it is to each of you.

As noted in my biography, I am the President of Georgia Research Alliance. We are a private, non-profit organization with an economic development mission. We were formed in 1990 from the vision of the business leadership of this state.

They saw the need to bring together business, Georgia's leading research universities and state government in a partnership to ensure that the innovation capacity of our university research enterprise was directed toward bringing economic prosperity and a superior quality of life to Georgia, the region and perhaps the Nation.

The stated goal was, and is, for Georgia to be recognized in the top tier of states with an innovation-driven economy. Why is it important for Georgia to be thought of as a high-tech state? It is well known, certainly by this committee, that high-tech jobs—especially the jobs in fields such as computers and communications or the biosciences, attract our most highly educated workers who in turn earn the highest salaries. This high-tech workforce is the key to building very successful, growth-oriented companies that lead to sustainable economic growth.

High-tech industries are in fact characterized as the ones that are driven by entrepreneurial energy and imaginative thinking. These are the industries that develop the sophisticated tools which impact businesses of every size and translate discoveries made in our research laboratories into the technological advances that are so important to our quality of life.

We see a situation today where the development and use of technology is strongly influencing the distribution of economic growth in the United States. Clearly this distribution of economic growth is not occurring uniformly in all states and regions. Economists of course have a name for this, they call it geographic clustering. What it means very simply is that there are going to be the proverbial haves and have-nots. There will be winners and losers. Our challenge, the challenge from our board of trustees, the expectation of our Governor is ensuring that Georgia does emerge as one of the winners. But an even greater challenge, and certainly one that this committee is concerned with, is to make certain that America sustains its reputation as an innovator and continues on a path to prosperity.

Over the past 13 years, Georgia has been quite successful in moving toward this goal. We have brought a cadre of some of the world's brightest and best researchers to our universities. We have provided them and their colleagues with the specialized laboratories and equipment they need to lead research and development programs with significant economic development potential. And we have created programs to move innovation from the laboratory to the economy.

In fact, we can track some 120 new high-tech startup companies that are related to our investments in recruiting top scientists and developing a world-class university research infrastructure. This is the good news that I have just shared with our Governor as our legislative session gets underway in Georgia.

But all of this success will fall apart unless we are able to meet the challenge that this committee is addressing. We must be able to provide a workforce with the math and science skills that are so vital to helping these companies grow, and our more established ones thrive.

We also need to continue to build a university research workforce that generates the innovative technologies that lead to more growth of the high-tech industries in our state.

The statistics in Georgia are disquieting, particularly to an organization such as ours that is expected to improve the economic landscape of our state. As I understand our situation, in the year 2000 our 4th graders ranked 43rd nationally in science and our 8th graders ranked 42nd. Our percentage of college students seeking degrees in science and engineering continues to fall. Women and minorities are still under-represented in the sciences and engineering. And all of this while the retirement of the baby boomers is expected to leave a two million job gap in professional, technical labor markets.

Recently Georgia came in second in its efforts to recruit a major vaccine manufacturing facility to the state. Mr. Chairman, second really doesn't count in this business. The facility went to North Carolina. One of the key reasons cited was the perception that Georgia could not provide the high-tech workforce that such a facility requires.

So we know that we have a challenge. But I am pleased to share with you a few things that are happening in Georgia that can help us to move forward.

Last June a group of Atlanta entrepreneurs and educators from several universities and secondary schools began meeting informally to discuss what could be done to improve science education for K through eight students in Georgia. They have since formed the Georgia Alliance for Science Education to develop a blueprint and action plan that will ensure that all Georgia students become scientifically literate citizens of the 21st century. They have also joined with the National Science Resources Center, the National Academies and the Smithsonian Institution to sponsor a Call to Greater Collaborative Action, a conference on improving science education programs for Georgia's K through eight students. This is particularly noteworthy as it is a grassroots effort intended to deal with a giant problem. And as I will recommend to you, this initiative will be driven by a public/private collaborative.

Finally, let me speak on a personal note. I have two young sons. The older one wants to be a fireman when he grows up. This has been his ambition since before he could talk. I believe he has stayed committed to this goal, in part, because he has role models that he can see and understand and talk to and brag about to his friends. And believe me, every day my wife and I try to impress on him that he needs to understand his math studies because today firefighters are expected to be part engineer. So we have some leverage. But in the high-tech world, in the world of science, engineering and math, we have not presented role models for our kids. We have not demonstrated how the research scientist or the entrepreneur or even the electrical engineer can be a hero, improve our lives and maybe even save lives.

I will close with two suggestions. One from a professional perspective and one from a personal perspective. The challenge ahead will require the close collaboration of business, the educational system and our political leadership to truly meet the challenges that you are addressing and to find the answers that you seek. But let me be clear. By collaboration, I mean the active participation of all parties, not merely one sector turning to another asking for more money. An active collaboration is what has made the Georgia Research Alliance successful, and I believe that such a model will be the right basis for what you are about.

And from a personal perspective, let's show our kids some heroes from the world of math and science. Let's brag about what they have accomplished and what it means to our nation and to the world.

Again, thank you for the opportunity to speak with you today.

[Applause.]

[The prepared statement of Mr. Cassidy follows:]

PREPARED STATEMENT OF C. MICHAEL CASSIDY

Mr. Chairman, esteemed Members of this committee—good morning. My name is Michael Cassidy and it is a distinct pleasure and honor for me to join in this discussion today and to provide testimony to this committee on a subject that is of great importance to me professionally and personally, as I am sure it is to each of you.

As my biography notes, I am President of the Georgia Research Alliance. We are a private, non-profit organization with an economic development mission. We were formed in 1990 from the vision of the business leadership of the state.

They saw the need to bring together business, Georgia's leading research universities and State government in a partnership to ensure that the innovation capacity of our university research enterprise was directed toward bringing economic prosperity and a superior quality of life to Georgia, the region and perhaps the Nation.

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Clearly, this distribution of economic growth is not occurring uniformly in all states and regions. Economists of course have a name for this—they call it geographic clustering. What it means, very simply, is that there are going to be the proverbial haves and have-nots. There will be winners and losers.

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We also need to continue to build a university research workforce that generates the innovative technologies that lead to more growth of the high tech industries in our State.

The statistics in Georgia are disquieting, particularly to an organization such as ours that is expected to improve the economic landscape of our State. As I understand our situation, in the year 2000, our fourth graders ranked 43rd nationally in science and our 8th graders ranked 42nd. Our percentage of college students seeking degrees in science and engineering continues to fall. Women and minorities are still under-represented in the sciences and engineering.

And all this while the retirement of the baby boomers is expected to leave a two million job gap in professional technical labor markets.

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And from a personal perspective, let's show our kids some heroes from the world of math and science. Let's brag about what they have accomplished and what it means to our nation and to the world.

Again, thank you for this opportunity to speak with you today.

BIOGRAPHY FOR C. MICHAEL CASSIDY

Mr. Cassidy is President of the Georgia Research Alliance, a strategic partnership of Georgia's research universities, joined by the business community and State government, whose purpose is to leverage the State's research capabilities into economic development results. Before joining the Alliance in 1993, Mr. Cassidy managed the Advanced Technology Development Center (ATDC), Georgia's technology incubator. Prior to that he worked for the IBM Corporation were he held various staff and management assignments. Mr. Cassidy holds a Master's degree in Technology and Science Policy from the Georgia Institute of Technology and a BBA degree in Marketing from Georgia State University.

Mr. Cassidy represents the State of Georgia on the Southern Technology Council and the Southern Governors' Association Advisory Committee on Research, Development and Technology. He consults with several states on issues of science and technology policy and economic development. Mr. Cassidy is on the Board of Directors of the Southeastern Life Sciences Association, Georgia Advanced Technology Ventures, the SciTrek Museum, and the Georgia Chamber of Commerce. He is on the Board of Visitors of the Grady Health System and a member of the Commerce Club of Atlanta. Mr. Cassidy enjoys sailing, swimming and walking.

GEORGIA RESEARCH ALLIANCE

January 14, 2004

The Honorable Sherwood Boehlert
Chairman, Science Committee
2320 Rayburn Office Building
Washington, DC 20515

Dear Congressman Boehlert:

Thank you for the invitation to testify before the U.S. House of Representatives Committee on Science on January 23rd for the hearing entitled "Fueling the High Tech Workforce with Math and Science Education." In accordance with the Rules Governing Testimony, this letter serves as formal notice that I received no federal funding directly supporting the subject matter on which I will testify, in the current fiscal year or either of the two proceeding fiscal years.

Sincerely,

C. Michael Cassidy
President

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50 Hurt Plaza
Suite 980
Atlanta, Georgia 30303
(404) 332-9770
Fax (404) 332-9776

DISCUSSION

Mr. GINGREY. Thank you, Mr. Cassidy.

That completes the formal testimony of our witnesses. I know the students who are in attendance here this morning at this Full Committee hearing of the House Science Committee have been rotating in and out, of course, depending on class schedules, and you may not have heard the full testimony of each and every witness. They are submitting—have submitted a written report and, of course, that will be eventually available in the *Congressional Record.* But if any of you want one or all of these written testimonies, I can assure you that we will get them to you.

We will now get into the next phase of the hearing, the Q&A phase. I think Congressman Davis would agree with me that we all, Members of Congress, have a lot of town hall meetings, we call them in our districts. This is a very important part of what we do in regard to constituent services. But I have—and I am sure he would agree—I learn more during that phase where we let folks ask questions of us. It stimulates a two-way dialogue. A lot of times we might not know the answer to a question, but then we get an opportunity to go back and find out exactly what we need to know. So this really—if you miss some of the actual testimony of the participants, the best part is what we are getting into right now. I understand we do have some time where we will be taking questions from the audience for any of the participants.

I am going to start the questioning and after a short period of time, then I will turn that over to Congressman Davis and then we will follow with questions from you.

Let me start actually with Mr. Cassidy. Mr. Cassidy, not long ago there was a *Business Week* cover that asked the question: "Is Your Job Next?" Clearly the issue of offshore out-sourcing and American competitiveness is of great concern to Georgia and to the Nation as a whole. We all read every day about loss of more manufacturing jobs. Just recently in this 11th Congressional District, of which we are a part right here in South Cobb, down in Troup County, in LaGrange, we lost another 550 jobs when West Point Stephens, a textile manufacturing plant announced impending layoffs.

I believe the key to American competitiveness is competing on our own terms, not trying to see who can pay their workers the least. How do you think we can remain competitive, and what role does education and training play in creating our comparative advantage against these other countries that are taking some of our jobs?

Mr. CASSIDY. I think the key, Mr. Chairman, is continued focus on innovation. You are familiar with the work of the Council on Competitiveness and the issues that they are looking at of how to continue to fuel innovation in our country. It was not that long ago that industry aligned and began to look at the issues of moving jobs offshore, but specifically in the manufacturing area. While this was of great concern to a number of us in the country, it really did not capture our attention because we were sure that our future would be based on the expansion of a high-technology economy of research and development, but today, we see these same jobs going offshore. So we are just going to have to continue to pour our efforts into innovating, to leading to discoveries that have really led our country to the heights that it is at today. All of this will require strength in mathematics, in the sciences, in the engineering and it has to start, as we have heard from our other panelists this morning, at the very early stages where we can capture the enthusiasm of our children so that they will want to pursue these degrees going forward. We have to sustain that workforce. Other countries are way far out ahead of us today.

Mr. GINGREY. And I asked that—thank you, Mr. Cassidy. I asked that question because while there is no question that we have lost a lot of manufacturing jobs, not just in Tennessee and Georgia, but across the Nation, manufacturing jobs are actually being lost worldwide. While we may have taken a little bit more of a hit than China and some of these other countries, we are still losing manufacturing jobs. The point is, it is because of increased productivity. It is not just that we are losing jobs necessarily to these other counties. There is some of that of course. But the fact remains that technology, high-tech—and as you pointed out, an increased emphasis on math and science and engineering are going to hopefully create more and better jobs for the future.

This is a question really for all of the witnesses. According to a survey by the United States Department of Education fewer than half of high school seniors surveyed indicated that they liked mathematics, a proportion similar to the proportion who felt that they were good at it. What effect does this math anxiety have on student achievement and what can we do to overcome it? I think I will ask our student valedictorian, Ms. Purcell, to take that one first.

Ms. PURCELL. I find I enjoy math most obviously when I understand it. There are some things where you need the concept gone over many, many times. I personally struggled more with very abstract things. I guess there is not as much motivation to try to understand it if you do not feel you will need it. I think some of my peers, not so much in the IB program, but others taking calculus, if they do not understand, they kind of feel like, well I will not need it, so I do not have to worry about struggling to understand it. I think that is probably the biggest problem with students saying that they do not understand their math. Especially my peers in their senior year are taking a class, but they do not feel they will need it in their career, they are not going to want to spend a lot of time studying their senior year and worrying a lot about not understanding their math subjects. So I think that if some of them maybe had had an opportunity to take it earlier when they were a little more focused on high school success, and not looking so much toward next year in college, that they may have put more effort into it or gone in to get after-school help and such.

Mr. GINGREY. I thank you, Ms. Purcell. You know, again, the reason I asked that question—and I want the other witnesses to respond as well briefly. But I am sure there is a certain amount of grade point average fear in signing up for the tough math and science courses. What do the other witnesses feel about that? Let us just go right down the line briefly.

Mr. MCCLURE. Mr. Chairman, science and math obviously are very closely interrelated. I think one of the biggest things is presentation. That is where we have to constantly work and go back and hone our skills as teachers. Students have to come with a certain amount of skills and it begins day one. If we do not attack them when they come with a mind willing to learn and take advantage of that, it is pretty hard to go back and recapture that a little bit later on. If somebody gets weak in math skills we have to now develop a program that allows them to catch up to where they should be when they start out. That sometimes is a problem because if they do not have success in that program you created to catch them up, then they get frustrated. I think the biggest sell is to say first of all you can do math. We have to stop telling people about how hard it is and show them ways to do it. When I first started out in science, I hated science, but I got a teacher who showed me some ways that I could work in science. Since I was a high-school athlete, he said if you practice this stuff this way—and I use that in my class. It is probably 90 percent presentation, what we really need to focus on in order to create—because we have to create an atmosphere of excitement. Nobody wants to do anything that is boring. Math is certainly not boring, it is a key that we have to have. So I think presentation is a big role.

Mr. HILL. I will—I will second those comments. I think the role that the state—the Department of Education and the state can play is ensuring that teachers have all the necessary tools, such that they can make those exciting presentations. We need to stress content knowledge in science and math and revising the quality core curriculum or these performance standards and providing examples of what it means to have a quality presentation in a certain subject area so that Mr. McClure can compare his presentation and his students' work to high quality work in California, high quality work in New York. I think a lot of times teachers unfortunately do not have access to resources that are present across this country and the role that we can play to provide access to those resources to ensure that there is content knowledge and ensure that there is ongoing training or staff development.

I am sure you can remember when you were in the state legislature, it seemed as if there was always a notion to cut staff development, to cut professional development. If someone had already gone to school, why do you need to continue to provide training? There are always new things coming on in science and new ways to teach math. So we just have to make sure the resources are there so that the teachers and the students can do a good job in those subject areas.

Dr. OHME. I think Ms. Purcell hit the nail on the head when she said that she enjoys it when she understands it. I think that is true of all of us. If we do not understand something, we tend to shy away from it. I think that beginning early on with our young people, we must ensure that they get a conceptual understanding of the topic. Certainly there are certain basic skills that have to be mastered to understand what skills go with the concept. That is driven sometimes by assessment. So I think when our assessment is based off of simply facts of basic computation and not looking at conceptual understanding early on, we as leaders are guiding people away from the concepts. When it's based off memorization, there is a limit as to how much we can memorize. Some students by sixth grade, their memorization fails them, some by ninth grade. I have seen students memorize all the way through freshman year in college and then hit a course of differential equations and that is where their memory work—memorizations would not work anymore. So if you want a student to understand, they have to understand the concept. The reference is also made that one way to bring understanding and relevance to students is making sure it is done in an allocation setting. So you do not do the mathematics for mathematic's sake purely, but you do the mathematics as well as its applications and bring out the applications.

This comes back to the in-depth knowledge of the subject matter. A teacher who only surfacely knows the material is not going to be able to stress concept or application. This is where we can use our university people, research and mathematicians, scientists and engineers to partner with the teachers to help bring the concepts, bring the applications, bring current the applications. Then we make sure that a child does not go from grade to grade without mastering concept.

Mr. GINGREY. Mr. Cassidy.

Mr. CASSIDY. I think there are two things that I would mention. From my own experience, math was not a strong point. It was a long time ago when I was in high school, but our football coach was my math teacher. I hope things have changed, but I fear that today we still have far too many teachers in math—especially in the sciences—teaching out of field. I know a good deal of that is related to budget constraints and this is not a good time to be talking about that, but I think something does have to be done to address the issue of teaching within field and then really following on what each of the others have said having those teachers be able to connect with their students.

Now one other item is the use of technology in the schools today. While I am a very, very strong proponent of technology-enhanced learning, all the new devices and web-based and computer-based tools and techniques to help teach kids science. Ms. Purcell talked about the excitement of cutting open the calf's heart. Well, we got to do those things in school when I was a kid and that made science exciting. I do not know if it is as exciting looking at it on a computer screen today. I am not sure that that captures the enthusiasm. You certainly do not have the smell of formaldehyde all over you.

So while we need to continue to look at all of the wonderful things with technology-enhanced learning, I think there are appropriate applications and there are other times when kids just have to be able to experience things the way that we did when we learned science.

Mr. GINGREY. I want to thank all of you for those answers. I had a follow-up question but I am going to hold that because I have gone way beyond my time. I think at this point I will turn it over to Congressman Davis for some of his questions.

Mr. DAVIS. Again, thank you for the testimony you have given and for the response to the questions that you have given us as well.

In your comments, Mr. Cassidy, one of the things that you alluded to is that we probably need more role models, more than just sports figures, more than movie stars or musicians or those who make huge sums of money. We need someone whose life has been successful. We have some of those, folks like Bill Gates. As we review the last 100 years of aerospace, Orville and Wilbur Wright, which certainly was a part of my upbringing to study about that and look at how we have evolved—not evolved, but how we have through research and development, education and knowledge, that we have gone from that small lightweight plane that flew for a few hundred feet to what we are doing today in aviation. So we do have those, whether it is Eli Whitney; George Washington Carver, one of the minorities, was an investor and inventor in agriculture in our country. So we still have those role models. I think sometime we do not do enough at the high school level, K through 12 or K through 8 to remind our children, our students, that these are folks that you can pattern your life after.

And in making that comment, Dr. Ohme, you basically said that we have to prepare teachers better. We need to bring not just better educated teachers but teachers who can relate to the student in the classroom to where that child will learn from that teacher. When I grew up in the small community I grew up in, my grandparents lived close by. They were role models for me. Not as much of a role model as my parents, my mother and my father. But probably perhaps outside of my family, the biggest role model that I had growing up was the teachers. I can tell you their names, how they felt toward me, and how I felt toward them. I do not know whether we have lost that or not. I certainly hope that we have not. I do not think my daughters when they went to grade school and high school as they related their stories—they still have those feelings that that teacher is a role model to them. But I think that we are seeing changes made in how we look at education.

The question I guess that I would ask each of you, Mr. McClure, Mr. Hill, Dr. Ohme, maybe Ms. Purcell, even you because you are a student: what approaches are possible for attracting more qualified individuals including mid-career and retired scientists, mathematicians and engineers to careers as science and math teachers and particularly to attracting minority candidates, perhaps? Either of you or all of you. And what are we doing today?

Mr. HILL. One program that the State of Georgia has implemented is Georgia TAP, basically which is an alternative certification program. It allows those folks who were in careers other than education to maybe make a mid-career adjustment, make a mid-career change. Those folks do not have to go through a college of education but they have to show and demonstrate that they have content knowledge by passing the so-called PRAXIS Test. All of the testimony that I have heard with regard to the PRAXIS Test in math, if one achieves a passing score on that test, they clearly understand the content knowledge of math. But I think we cannot ignore the teaching side of it because I am sure we all had professors in college and graduate school who were brilliant but could not convey the knowledge that was inside their heads.

So the alternative education program that Georgia has enacted requires not only content knowledge but some type of mentorship and training to expose these different individuals to what it means to teach. It is very important in elementary and in K–8 I think to ensure that you can connect with these young kids, maybe less important in high school, but it is still very important.

Ms. PURCELL. In the IB Program—I am sorry. In my experience my teachers are a wonderful group of diverse and accomplished individuals. Many of them were professionals before they became teachers. I think that they choose to teach and they love to teach because they get to teach a group of students that really want to learn. My peers and I are very much interested in learning and in succeeding. I think that drives them to continue. It is not so much of a chore, it is a more positive experience. I guess then you are back to the same question, how do you make the students want to learn? I think those two things go hand in hand.

Mr. DAVIS. I sense that you have a special school here. You are obviously—it is special when you talk about being 99.5 percent in the top category. That is extremely special, if you are from any part of this nation, to be in that category.

Are the students here from the surrounding communities or do they live in this neighborhood? I mean how has this—from your perspective, how has this high school become so successful?

Ms. PURCELL. Personally I—the IB Program pulls from all Cobb County, so they do not live close by. But I was districted to come to this high school anyway. So I have maintained ties I guess with the regular student body who do live in this area. I think that obviously the IB Program has helped make it more successful just because interaction with different kinds of people who have grown up in different areas. The success comes from both sides of the, I guess, Campbell student body.

Mr. HILL. I think there are several points I want to mention. One, I think the profession does not have the honor and recognition that it probably did in earlier decades. I think we must analyze ways that we can bring prestige to the profession. If you look at the starting salary for a teacher versus an engineer, it is not necessarily encouraging.

The second thing I want to look at is the retention rate of teachers in their first three to four years of teaching. We find that there is a tremendous loss of teachers in that period of time. I think we have to look at that seriously. I think the working conditions of the teachers is not conducive to encouraging teachers to stay. If you're an engineer and you need a couple of hundred dollars worth of supplies, most likely your firm would provide them to you, yet we find teachers buying supplies out of their own money. It is not so much the $200, that is a give or take kind of thing. But it is the image and the perception and the concept.

We also find that there is a correlation not so much between the poverty and the background of the student and success as we do with the quality of the teacher and the success of the students. And so we need to look at programs that bring our best teachers to the more difficult teaching situations. There are rural situations, urban situations where the teaching is more challenging. We need to find a way to motivate and move our best teachers.

Mr. DAVIS. I have three teachers in my family, a son-in-law, a daughter and my wife. She teaches second grade. There are numerous occasions when I am traveling in the northern part of the district I represent that someone will tell me, your wife taught me in second grade, and I love it. My little six-year old granddaughter, Ashton, asked her mom the other day, she said, mom, or mother, why do all the little kids hug you? She was afraid her mother was going to start loving the little kids more than she did her.

[Laughter.]

Mr. DAVIS. So I think we still have today that feeling, at least in the rural areas, that the teacher is kind of something special. I hope that we can keep that going.

Dr. Ohme, I am running out of time. In your testimony you characterized the NSF Math and Science Partnership Program as exemplary for engaging K through 12 educational practitioners in math and science and university faculty in advancing science and math education in the schools. There is a persistent rumor, maybe not true, that the upcoming budget proposal for fiscal 2005 will move the NSF program to the Department of Education. What is your view on the overall impact of such a proposal and does it make sense to maintain separate coordinated partnership programs at NSF and the Department of Education?

Dr. OHME. That is an excellent question, sir. The role of the National Science Foundation and the role of the Department of Education are two distinct roles. The role of the National Science Foundation, as I understand it, is a research, very narrow type role. The use of scientists, mathematicians and engineers into a K–12 setting is something unique, something we have not done more than a year or two. And the money that Congress allocates for math/science partnerships is for the express purpose of bringing that group of people into the schools. For us to spend millions of dollars on a program without having tested it, experienced it, done some research on it and identify some best practices I do not think is sound judgment. So I think to continue an allocation to the National Science Foundation to prototype programs, to go out to different distinct situations, test out some strategies, find out what works and what does not work and then communicate this body of best practices to the Department of Education that is typically given a large amount of money typically allocated in a block grant or by formula or something based on population and need, and be able to carry them and say here are some things that we know work in these situations, here are some things that we have found do not work in these situations, put this in your repertoire of spending money.

So I think that at least at this point in time, where we have a scenario that's new, we need to be able to gather more data. I think all of us can identify some college faculty members who if thrown into a K–12 situation are not going to be effective. But yet we have some situations at Tech where it is extremely effective and we outlined some of those programs in our testimony. So I think it can happen, but we need to document what those profiles are before we put massive amounts of money out.

Mr. DAVIS. Thank you very much. I yield back to Congressman Gingrey.

Mr. GINGREY. Congressman Davis, thank you.

Mr. Arnson, I think at this point we will get into questions from the audience. I want to remind members of the audience who are participating in the hearing that your questions can be to any one of our witnesses or to the entire panel. So at this point we look forward to hearing your questions.

Yes, sir. Let me—just a minute. I guess in the interest of making sure that everybody can hear your question, we are going to ask you to come down and come to the main microphone here.

Mr. BUTLER. [Inaudible.]

Mr. GINGREY. Members of the panel, could you hear the question?

Ms. PURCELL. No.

Mr. GINGREY. Okay. That is not your fault. The sound system may not be as good as it needs to be. Can you actually, you know, act like you are on one of these TV shows, what do you call it, the one where——

Mr. DAVIS. Reality.

Mr. GINGREY. Reality, there you go. And just put that thing right in your mouth.

Mr. BUTLER. I have a question for this panel. Most of you all referred to math and science organizations for the future. I just want to know what type of math organization—math and science organization were you all planning for today, the present.

Mr. DAVIS. I think what his question is, is that we are talking about the future of math and science. His concern and interest would be what are we doing today in math and science. Is that correct?

Mr. BUTLER. Yes, sir.

Mr. MCCLURE. I will address that for you, Mr. Butler, since you are in my class during this period.

[Laughter.]

Mr. MCCLURE. One of the things we are going to do is try and give you a good base in science so that you will be well qualified when you leave Campbell High School to go out and participate in science on any level that somebody leaving high school could be best prepared for. There are lots of things that are available to you. There are all kinds of science organizations, you know, here at the school. We have a chemistry club, we have lots of things that you can avail yourself of. Probably the most important thing for you to be aware of right now though is Chapter 2 and the chemistry that we are studying.

[Laughter.]

Mr. BUTLER. Can I ask another question?

Mr. GINGREY. Yes, sir, sure.

Mr. BUTLER. He spoke on—Mr. Cassidy, he spoke on coaches teaching in the math and science classrooms. I would like to know how you feel about that because Mr. McClure is a coach and is in the science classroom.

[Laughter.]

Mr. CASSIDY. Well, now there is a difference. There are those that are trained in math and happen to coach in their spare time and there are those that are trained as coaches and because of constraints have to come into the classroom and take any number of different subjects. I think it is great when it works. My point is, I think in fields like mathematics and especially in the sciences the needs are so unique, the subject matter is so unique that as each of the panelists have noted, teachers must be properly trained both to handle the subject matter and also hopefully to get you very enthusiastic about that. Now your football coach maybe can get you very enthusiastic about math. He can perhaps make it very, very applied. There is a lot of math in football and in basketball. I had an econ professor who was a big enthusiast of basketball. He could take a very complex economics problem and explain it in terminology that basketball players—and that is great. But math and science require very, very specialized skills. I think we just need to be making certain that our teachers do have those skills, and if they also want to participate in coaching and sports, I think that is outstanding—or any other extra curricular activity that they want to pursue with the students.

Mr. GINGREY. Mr. Cassidy's answer, while somewhat accurate, I have to remind him that this is a no-spin zone in regard to some of the math and science that is applicable to sports. But certainly he and I realize that there has been a paradigm shift since the time that we both went to high school. I think your question is a great question, because it is true that years ago principals—Mr. Arnson would hire a football coach or a basketball coach primarily because they wanted a good coach. Then after they decided to hire that individual, they would say oh, by the way, the class that you are going to teach is calculus, because they had to teach as well as coach because primarily they are teachers. I think that the paradigm has shifted.

I am so glad you asked the question, because I think today what you are seeing is principals like Mr. Arnson and others who are serving us so well; when they hire coaches, it is a secondary goal. Primarily they need to be good teachers. Coaches that you now see teaching in our school system are well prepared and have great mastery of their subject matter and they just happen also to be good athletic coaches.

All right, we are going to limit you to two. Thank you.

Who is next?

[Student raises hand.]

Mr. GINGREY. Yes, sir, come on down.

[Applause.]

Mr. DAVIS. While we have the young gentleman coming, what I am impressed with is that these young folks are listening obviously because they caught the comment that was made. And truly the football coach is part of math. Georgia Tech and Cumberland University have I think the highest football score in the history of this country. You have to be able to have some mathematical skills to add that score up. It was a horrible score. Cumberland University is in the central part of Tennessee. But one of the analytical parts of football is when it is fourth down and 25, the analytical math part of it is you punt.

[Laughter.]

VOICE. I have a similar question. My name is Matthew and I teach chemistry here. You talked earlier about training and retaining and attracting the best teachers to not only Georgia but to any school in the country and I was interested in what Coach McClure had to say about that. Not just because he is my boss, but because he is one of the science teachers and someone who has first-hand experience, I would just like to let the audience and the panel have a chance to hear what he would have to say since he was not able to speak on that earlier.

Mr. McCLURE. I appreciate that, Matt. You know that is something—and I listen respectfully to a lot of comments. A lot of times we do get a lot of input about teaching. I guess as—you know, we still consider teaching a royal profession. Maybe everybody does not consider it that, but I know teachers do and I certainly do. I have a lot of comrades who do a great job. It is somewhat dismaying sometimes though—we have all had brilliant professors that are masters of a subject matter, but have an inability to communicate. To me that is equally as important or maybe more important, being able to deliver. It is salesmanship. If you cannot sell it—that is why students sometimes do not like certain subjects. You cannot just beat up on math and science because I think it would be true across the board. It is salesmanship. You know, you can maybe know less—and that does not mean that you are not qualified.

I am glad that he asked the question. I am a biology major with a chemistry minor. That was what I started out to do, and they asked me if I wanted a job, could I coach. So I did go the opposite way with that. But you have to be able to sell it. If I go to your class and you write with one hand on one board and erase with the other hand on the other board, that is all you do for me and say have a nice day, I am not going to be interested in whatever you are trying to tell me about. I think that is the key to it. It is a little difficult to accept genuinely the idea of someone taking a three-week course and being considered a teacher. You could not do that if you wanted to be a lawyer or if you wanted to be a physician. Yet somehow we have reached the point where we think that teaching could be done that way. Perhaps those who make decisions along that line need to spend a little time with us so they could really realize what really goes on, because I think the retention rate of those people who make those changes sometimes is not very high. I think what they realize when they come into the classroom is that there are a lot of variables that teachers have to deal with in addition to knowing the subject matter and being able to present it.

There is a story told—I will make it brief—about a business leader who was getting on the teachers and trying to encourage them to do the very best they could. This person was a blueberry salesman, and the person said that, you know, what we do is we make the best blueberry pie in the world. We get the blueberries, we make the pie and we send it out. There was an old teacher in the back of the room who pointed out the fact, yeah, you can do that, you can make the best blueberry pies, but you can choose your blueberries. Unfortunately in education we do not get to choose that. We take what comes and you have to use a skill. It is a calling to be able to teach. It is a blessing to be able to teach, but not everybody who is gifted in the subject area can have the ability to deliver.

[Applause.]

Mr. DAVIS. You have proven that cloning is a great idea. I wonder if we could clone you and make all the teachers in America like you?

Mr. GINGREY. We have plenty of time students. So we will be glad—oh, good, we will take our next question.

VOICE. Good morning.

Mr. GINGREY. Good morning.

VOICE. I have heard some of the panelists talk about teachers needing technological improvement in tools to enhance the learning environment to inspire students. My question is directed toward the Congressmen. What kind of funding would the Federal Government provide to make these technological improvements happen?

Mr. GINGREY. That is a very good question. One thing that I have learned in the Congress, and I certainly learned that prior in the Georgia General Assembly, is that everything is based on priorities. You have a certain amount of revenue to spend. Now states have to balance their budgets. I wish that the Federal Government had the same constraints. But even if we had a balanced budget amendment, Constitutional amendment, in Congress, the exceptions would be in times of national emergency or times of war, and we find ourselves today in both situations. So you are seeing some deficit spending that none of us like.

Our budget this past fiscal year, 2004, was $2.3 trillion. Now think about that, $2.3 trillion. That is a lot of zeros. Two-thirds of that money is for what we call nondiscretionary mandatory spendings, Social Security, Medicare, things that we—no matter what, money that has to be spent. It is very difficult to cut that part of the budget because promises made are promises that have to be kept. People are living longer, there are more recipients of those entitlement—sometimes called entitlement expenditures. So only about $\frac{1}{3}$ of the budget is what we call discretionary spending and, of course, education, K–12, higher ed, Head Start. You know, from three-year-olds all the way up to college and beyond is a part of the discretionary spending. Oh, guess what, so is the Department of Defense and the need to have a strong military, and the Department of Homeland Security and the need to protect each and every citizen so that when these youngsters like yourselves and your little brothers and sisters go to school every day, you do not have to have that great fear that something like 9/11 is going to happen to them or yourselves, and your parents and grandparents of course have that same great fear.

So those are the constraints that we find ourselves in. And even with that, this administration has increased fairly significantly the amount of spending on education. But certain line items may not be to everybody's satisfaction in regard to things like special education and as you point out technology and the need for additional spending. I wish we could do everything that we need to do, but unfortunately there are some constraints there. But I truly believe that in this state and hopefully in the state of Tennessee and throughout this nation that we—maybe we are spending enough money, but possibly we are not spending it as wisely as we could or should. You know, you have always heard the admonition to work hard, work hard, but you need to work smart, too. Sometimes people work very hard but not very smart, and the same thing regarding spending. It is not just a matter of throwing additional dollars at it, it is looking for the programs that work and the programs that do not work and accountability. In fact, that is what No

Child Left Behind is all about. So it is a great question and I appreciate it. I would be interested in how Congressman Davis feels about that, and maybe any of the witnesses might want to comment.

Mr. DAVIS. I will make a brief comment. Recently flying back to Washington I picked up a local telephone cooperative magazine called the *Tennessee Magazine*. The front page said, "A Better Educated America," and I was excited about reading that story. It was about half a page. It related to the 1940 census compared to the 2000 census, and I wanted to compare the district I represent to the national average. In 1940 less than one out of four people who were over the age of 25 had a high school education or better. This was 1940. It is eight out of ten today. It is 80 percent today. That is not good enough, but it is much better than it was 60 years prior to. One in 40 people had a BS degree in America. Now one in four has a BS degree or better over the age of 25, and 80 percent had a high school education or better. So I checked the congressional district I represent. 400 some odd thousand people lived in that district in 1940. A little over 11,000 had a high school education or better. 2.7 percent of the population had a high school education or better. Two of those people who did not have a high school education, like many others I know, were my parents. Why did they not have a high school education? One-teacher school buildings was the norm for those poor communities. And York High School in Jamestown was built by Alvin C. York, Sergeant York, in the late 1920's and was too great a distance for my parents to travel to, that only high school in that area. No transportation. We were not funding public education adequately. Basically we were leaving it up to small communities to do their own thing or in many cases faith-based organizations in the area that I am from, the Cumberland Plateau. And there are many foundations today, the Methodists, the Baptists, the Presbyterians. Foundations are all that is left. The buildings are no longer there. We made a strong commitment in the 1930's and 1940's to public education. As a result, we have seen dramatic improvements.

Are we committed to funding public education today as we were in the past? The Tennessee State Constitution says every child, regardless of where they live, every child will be afforded the same opportunity for an education as any other child in the state. We do not have that on the national level. We spend a little over $50 billion out of $2.3 trillion on education, and a large part of that goes to research universities, to institutions of higher learning beyond the K through 12 level. We do have many regulations and requirements as a result of federal funding, which in many cases brings an unfair, unfunded mandate to the local school districts.

So how do we change that? I think first of all, Representative Gingrey has been very accurate in saying there are a limited amount of dollars that are available. I believe if you look in the 1940's and 2000, the most important factor in a country's continuance as a democracy is to be sure that every child gets a great education. Bill Gates, in a recent trip that my wife and I took to that area along with several other individuals, many who serve in Congress, made the comment that was striking to me. He said we hire a large percentage of the 28,000 people who work here at this complex in Seattle, Washington, and what they build at Bill Gates' Microsoft you can carry in your hand. It is technology. It is a program. He said most of the folks we hire anymore, the largest percentage, are not American citizens, maybe educated in America's universities but from some other country. He said here is why. In most countries—in many countries there is a merit-based educational system, K through 12. We do not have it in America. His opinion was that we should not have. That we offer an opportunity for every child regardless of academic ability, social and economic values. In essence America made the commitment to every child K through 12. We do have merit-based in higher education. If you do not make the grade you are gone. You have got one quarter, one semester and if you are not at a certain academic level, you leave. So we have a merit-based system in higher education. We chose not to do that on the lower level. That requires a much larger commitment of funding to be sure that every child is educated to the level that they are able to reach. Should we change? I am like Bill Gates, I do not think we should. I think our system has been extremely successful. It has elevated us, in my opinion, to the most prominent country in the civilization of mankind. Do we need to fund more for education? You betcha. Will we be able to? Perhaps not. The thought in Washington is that most decisions being made is that, quite frankly, the funding for education should come from local and state agencies, and unless that changes, that will still be the driving force for funding for education in America.

Mr. GINGREY. Thank you, Congressman Davis.

Next question.

VOICE. I am a junior here at Campbell High School and I work in the Math Department and I often hear teachers talking about the curriculum. I often sit in the classrooms and see teachers having to speed through the text and not getting to actually students but fill them with information so they can pass the test. I am just wondering if there is any room in the future of math or science to get away from speeding through a subject because maybe a good student does not understand because they do not learn that fast, and giving them room to actually learn what they need to know so they can be successful later in life.

Mr. GINGREY. That is a great question. I think we will ask our witnesses to respond to that.

Mr. DAVIS. While someone is getting ready, I might add, this school itself is addressing part of the issues he is talking about, because you are bringing what we call in Tennessee a magnet school. You are bringing those who need to be challenged intellectually into a setting such as this here at Campbell.

Dr. OHME. A characteristic of the American education curriculum in contrast to many others in the world is that we have a lot of redundancy and the same topics are taught over and over again. If you look at the 6th grade and 7th grade math you will see it very much. There is a movement in Georgia, and this school has taken a lead here in looking at the curriculum and reducing the number of concepts that a student is expected to master in one year and having teachers focus on that, but then not going back and repeating. In other words, if you master it and you call upon it and you use it, the teacher does not have to go back. So if you start from the first grade and define a smaller number of topics per grade and concentrate on mastery, then you will build over a decade or so a system that I think would address the question that the young man asked.

Mr. HILL. And to follow up on that comment, Georgia's curriculum was audited by Phi Delta Kappa several years ago and basically the report says our curriculum was a mile wide and an inch deep and it did not provide focus at each of the different grade levels and the rewrite of the Quality Core Curriculum now called performance standards will provide specific content standards and expectations for each of the different grades for K–12—K–8, and for grades 9 to 12 specific content standards and expectations for each of the different courses. So I think we are definitely moving toward having clearer expectations and goals. With regard to assessments, there is an ongoing debate that I think will forever ask how much testing is too much testing and the other side of that, one might suggest that in order to ensure that students know the subject matter, you have to assess them as frequently as you need to so that you can then provide intervention or remediation or allow for acceleration for those students who have already mastered the content.

The steps that we have to take at the state is ensuring that the curriculum and the assessment and the instruction are all aligned so there is no redundancy.

Mr. GINGREY. Again, just as a little closing comment on the question. Obviously the concern over—particularly in regard to math and science—teaching to the test and because of that not having the opportunity to really pursue the subject matter in depth and have that good full understanding. I think as the witnesses have said, accountability also is very important. There is going to be kind of a transition phase, I think where we are going to have to realize that there will be some teaching to the test because schools are not going to want to be labeled as not making adequate yearly progress, but I think as this hearing indicated and the testimony from the witnesses, this improvement in math and science is going to need to start at the primary—indeed, even the primary school level, and there needs to be, in my opinion, coordination between your primary/elementary school teachers, your middle school teachers and your high school teachers. And a math department does not need to be three different math departments in a particular school system. I would hope that week that they spend before school starts, that teachers that teach math, whether in elementary, middle or high school level will come together and there can be an understanding of a longitudinal need that everybody is on the same page. But for the time being, there is going to be a little heartburn in regard to accountability.

We have time probably for one and possibly two more questions.

VOICE. I am a junior here at Campbell High School and I am in the IB program. First of all, I would like to say what an honor and a privilege it is to be here today and speak with you ladies and gentlemen about issues about school.

My question involves a comment, I am not sure who made it, Mr. Gingrey or Mr. Davis, but that American schools are not really that competitive on a global level as schools in other countries may be.

My question is, is there anything being done about that? Are there any plans to make our schools more competitive so we can more effectively compete on a global scale?

Mr. GINGREY. I appreciate that question. I think I was the one that made that comment and Congressman Davis may want to comment on this question as well.

I think it was the Governor of Michigan several years ago that led a group on a trip to Japan and some of the western European countries and came back and a report was given, an accurate report, that I think 15 industrialized countries were compared on math and science and the United States was pretty close to the bottom on both of these.

Congressman Davis in his comments just a minute ago alluded to maybe one of the reasons for that is this merit-based education that we see, I guess maybe in Japan and some of the western European countries—Germany—where if you are found to be maybe lacking when you get to the eighth grade, then you are channeled in one direction and the brighter students are channeled in another. And, you know, if we adopted that model, and to take it over to a sports analogy in regard to Michael Jordan, where would he be today if he had not been allowed to struggle through his freshman year when he did not make the basketball team. Sometimes people are late bloomers and that is certainly true academically as well. So it is a great question and it is something that we do need to address. I will turn the mic over to Congressman Davis.

Mr. DAVIS. In the comment from Mr. Gates—do not want to really refer back to him as being the authority, but in the comments, he said a lot of our employees now are coming from Singapore, India and China because of the merit-based educational system. Those who have been tried and tested move into certain categories. Therefore they may even be educated here in America because our universities perhaps are better. I am not sure, but he said many of those are educated here, even though K–12 they went through a merit-based educational system.

I think when you compare our K–12—I am not making excuses because we need to improve, but when you compare our K–12 to other countries that have a merit-based system, when you are talking about the high school graduate, you are comparing maybe not apples to oranges, but at least you are not making the same comparison of the academic achievements of every child going through high school and only a few reaching the 12th grade level maybe in some of the other countries.

I do not know that that is the answer as to where we are at, but I understand that when the Nobel laureates are given out, that generally over half of those in science are from American citizens and over half of the patents applied for in the world today are from an American citizen or an American company. That does not allude to the fact that we have a failing education system. It may be failing for some, but it is certainly not failing for all.

Mr. GINGREY. It is such a good question, I think we will let this be the last question and I will ask our expert witnesses who have testified here today to go ahead and try to address that. And again, the question—I will have you repeat it for them.

VOICE. My question was are there any plans, any ways that we could increase our competitiveness on a global scale with schools in other countries like Japan and India.

Mr. HILL. I would like to point to two initiatives at the Department of Education as undertaken over the last several years. One in particular this year, the State will pay for AP exams. AP exams, of course, are tied to not only national standards but to international standards. And another initiative that I want to highlight is the rewrite of the math performance standards. We actually looked at different national benchmarks and international benchmarks and settled on adopting the Japanese model for math. So what you are going to see within several years is that beginning in 7th grade through 12th, teachers of different math courses are going to include a standard algebra, geometry and data analysis or statistics and it is possible that within the next several years that the term algebra or geometry or statistics, those terms may not be the name of the different math courses where we are talking about maybe math 1, math 2, math 3, math 4, but that does not have a nice ring to it, we are going to have to come up with a better name, but we are definitely looking at Japan and adopting their model for K–12 math concepts and math standards.

Ms. PURCELL. I want to say that at Campbell High School, the IB curriculum, our scores on our tests are well above the world average. I do not know if it is really a teacher or, you know, Americans are stupider or dumber, but——

[Laughter.]

Ms. PURCELL. —we do receive a more elevated level of instruction and are taking the same tests as students in other countries, at least at this school and in the United States in general, we perform better.

VOICE. I am not necessarily speaking about the IB program here, but we do receive an advanced level of education, I was really speaking of students who are not on IB, who are receiving basic classes.

Mr. MCCLURE. I think that is a good question because I think Campbell being recognized in the top four percent is not just our IB program, it includes some other parts of our school, our AP scores I think were included in that, which are not necessarily our IB students.

But I think you cannot under-estimate the point that the Congressman made about students in Japan. In Japan, as I understand it, all of the students are Japanese.

[Laughter.]

Mr. MCCLURE. In America, it is a little bit different. We do not have one type of blueberry, and neither do we say to any of those blueberries that even though you messed up in the 3rd grade, you cannot go to the 4th grade ever. You may have to work at it a little bit, but you go. We do not say that because you messed up in the 3rd grade, you are going to be a farm hand, like I was raised on a farm, you do not get relegated to that.

So that has a big role in our educational system. I agree it is not just apples to oranges. We do a great job of educating what we have. We can do better, no doubt about that, but if you really had some other country to compare us to, I think when you take the best and the brightest that we have to offer, you see what it is that we are really doing. It would just take somebody from Japan coming to teach a class in America to really understand and appreciate what a great situation they have. It would be probably similar to teaching private schools here, where you can decide on who you want to have and who you do not want. Where in public schools, we do not want or get that luxury.

Mr. GINGREY. Thank you very much, and at this point, we are going to go ahead and wrap up. I want to first of all give Congressman Lincoln Davis from Tennessee an opportunity to wrap up and then I will have a few closing comments and then we will adjourn. Congressman Davis.

Mr. DAVIS. Well, it has been certainly a pleasure to be here today and listen to many of the students who have asked the questions that you have asked and for the testimony. Ms. Purcell, a student here, as well as the testimony of one of the teachers, Mr. McClure, and others, Department of Education as well as the universities here in Georgia.

I am excited about what I am hearing, especially from the students. It is exciting what I am hearing about the coach who also was a science and math instructor. I think America's future is bright because of individuals like you, those of you in this room.

Thank you for listening to those of us who serve in Congress and the panel that has been here today.

I can assure you, Mr. Gingrey, that there are two staff members—Joye and John over there—who may want to take this peach away from me, but they are not getting it.

[Laughter.]

Mr. DAVIS. It is good to be here. Thank you very much.

Mr. GINGREY. Congressman Davis, thank you.

[Applause.]

Mr. GINGREY. Let me just summarize for a minute. First of all, to thank our witnesses—Ms. Purcell, one of your own; Mr. McClure, indeed one of your own outstanding faculty members; and Mr. Hill, Dr. Ohme and Mr. Cassidy—how much we appreciate them taking the time out of their very, very busy schedules and how the important work that they do to be here and spend half a day with us this morning, how much we appreciate each and every witness who has testified.

As I listened to both the witnesses and Congressman Davis and the questions from the audience, it made me realize once again how important it is to have a Full Committee hearing of the United States Congress Science Committee here in my District in Cobb County, Georgia at Campbell High School—*Newsweek,* top four percent of the best schools in America. What a great venue to discuss this issue, this so important issue regarding fueling our high tech workforce with math and science education.

Congressman Davis pointed out something to me that is easily overlooked, that we compare the United States of America with these other industrialized countries, that we are not really comparing apples and apples, and he described the merit-based education that some of these other countries have. And it is so important to remember, I think, in closing here today that math and science and technology—at one point in our history maybe when some of us with a little bit of gray around the temple went to high school and college, everybody did not need to have a good understanding of math and science. But in today's 21st century where yes, we are losing a lot of these old cut and sew manufacturing type jobs that did not take great skills or much education. Everybody—everybody—today needs to have a good understanding of math and science. As I go around my District and there are a lot of manufacturing companies—Lincoln, I was just yesterday at a Honda plant in Haralson County, I was just at a clothing manufacturing plant in Carroll County, and the equipment that they use is so highly advanced, computer-based, and sometimes robotics. So math and science is important for each and every student. And that is why we are here today—to try to instill a lot of enthusiasm. As has already been pointed out by Congressman Davis, if we had more teachers like Mr. McClure, then I think every student could be a valedictorian like Ms. Purcell.

I thank all of you for coming. It has been a great hearing. And at this point, I declare this hearing over. Thank you very much.

[Whereupon, at 11:25 a.m., the Committee was adjourned.]